PROCEEDINGS

ELEVENTH ANNUAL MEETING

NORTH CENTRAL WEED CONTROL CONFERENCE

DECEMBER 6-9, 1954

FARGO, NORTH DAKOTA

PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING

OF THE

NORTH CENTRAL WEED CONTROL CONFERENCE

Fargo, North Dakota

December 6-9, 1954

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December 6, 7, 8, 1955

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PREFACE

The Proceedings of the Eleventh Annual Meeting of the North Central Weed Control Conference are a record of the formal papers and reports of the Conference.

Complete text of papers presented at the North Central Meeting are contained herein, unless for some reason they were restricted for publication.

Additional copies of this proceedings are available at $2.00 per copy, as well as the Research Report of the Eleventh Annual North Central Conference at $2.00 per copy, from F. W. Slife, Department of Agronomy, University of Illinois, Urbana, Illinois.

PROGRAM AND TABLE OF CONTENTS

Tuesday Morning, December 7, 1954

General Session, City Auditorium: Chairman: Oliver C. Lee

Welcome to Fargo
F. W. Mohr, Pres., Fargo Chamber of Commerce
Opening Remarks
Oliver C. Lee, Pres., NCWCC, Purdue University, Lafayette, Indiana 1
Weed Research Program of the U.S. Department of Agriculture
M. W. Parker, Head, Section of Weed Investigations, Field Crops Research, U.S.D.A., Beltsville, Maryland . . . .

Tuesday Afternoon, December 7, 1954

General Session: Chairman: K. P. Buchholtz

Effect of Weed Infestations on the Growth and Yield of Soybeans
D. W. Staniforth and C. R. Weber, Iowa State College, Ames, Iowa. (Abstract) 5
Rate of Leaching and Breakdown of Several Herbicides in Different Soils
G. F. Warren, Purdue University, Lafayette, Indiana . . . 5
A New Setaria Species in Illinois
F. W. Slife, University of Illinois, Urbana 6

Section I Botany and Physiology: Chairman: K. P. Buchholtz

Effect of Borate Additives on Herbicidal Qualities of 2, 4-D
J. D. Stone and D. W. Rake, Pacific Coast Borax Co., Los Angeles 5, California (Abstract) 7
Response of Russian Thistle to 2, 4-D and Additive Nutrient Elements
J. J. Sexsmith, Experiment Station, Lethbridge, Alberta . 8
Effects of Herbicides on Mitochondrial Enzyme Systems
C. M. Switzer, Iowa Agricultural Experiment Station, Ames, Iowa 10
On the Kinetics of Inhibition of Growth by Herbicides
R. E. Frans and E. F. Lind, Iowa State College, Ames, Iowa 12
Influence of Rates and Time of Application and Tillage Practices on Residual Effects of CMU
Lowell Jordan and R. S. Dunham, University of Minnesota, St. Paul, Minnesota 14
Factors Affecting the Disappearance of Substituted Urea Herbicides in Agricultural Soils
G. D. Hill, J. W. McGahen, J. R. Haun and V. L. Turner, DuPontCo., Wilmington, Delaware 15
The Correlation of Structure and Activity for a New Class of Herbicidal Chemicals
P. C. Hamm and A. J. Speziale, Monsanto Chemical Co., St. Louis, Missouri 16

Section II Regulatory and Extension: Chairman: D. W. Lambert

How Noxious Weed Infested Material Violations Can Be Handled
Dwight W. Lambert, Department of Agriculture and Inspection, Lincoln, Nebraska 18
The Council of State Governments and Weed Control Problems
Marvin Fast, Council of State Governments, Chicago, Illinois 19
Co-operation Between Research, Industry, Extension, and Regulatory Groups in the Attack on Weed Problems in Canada
E. G. Anderson, National Weed Committee, Department of Agriculture, Ottawa, Ontario 20
Essentials of a County Weed Control Program
Cecil Sanderson, Roberts County Agent, Sisseton, South Dakota 21

Results of the LaMoure County, North Dakota, Drill Box Survey
Henry N. Ness, Cass County Agent, Fargo, North Dakota 24
The Farmer and His Seed
J. D. Furrer, University of Nebraska, Lincoln, Nebraska 26
Weed Laws are Important - Panel
Sig Bjerken, Minnesota Department of Agriculture, St. Paul, Minnesota 25
V. W. Woestemeyer, Kansas State Board of Agriculture, Topeka, Kansas 28
Crawford Winton, Oklahoma State Board of Agriculture, Oklahoma City, Oklahoma 28
Charles J. Gilbert, State Weed Board, Brookings, South Dakota 29

Tuesday Evening, December 7, 1954

Banquet:
Chairman: E. A. Helgeson
Guest Speaker: Dr. H. L. Walster, Retired Dean of Agriculture and Director of Agricultural Experiment Station, North Dakota Agricultural College, Fargo. "North Dakota Agricultural College Battles Weeds" 29
Presentation of Awards 34

Wednesday, December 8, 1954

Section I Weed Control in Field Crops: Chairman: Lyle A. Derscheid (Wednesday Morning)

Control of Weeds in Spring Seeded Alfalfa
Paul F. Sand, University of Nebraska, Lincoln, Nebraska 36
Control of Grasses in Established Alfalfa with Dalapon
J. H. Davidson, Dow Chemical Co., South Haven, Michigan and F. W. Slife, University of Illinois, Urbana, Illinois 38
MCP, DNBP, 3, 4-D and 2, 4-D as Herbicides on Alfalfa Sown in Oats
Paul W. Santelmann, University of Maryland, College Park, Maryland and C. J. Willard, Ohio State University and Agricultural Experiment Station, Columbus, Ohio . . . 41
The Effect of Post-Emergence 2, 4-D Sprays on Growth and Development of Soybeans
F. W. Slife, University of Illinois, Urbana, Illinois 42
The Use of Dinitros on Corn (Abstract)
R. D. Ilnicki and C. J. Willard, Ohio State University and Agricultural Experiment Station, Columbus, Ohio . . . 43
The Effect of Some Chemical Weed Control Treatments on the Cultivation Requirements of Corn
O. Hale Fletchall, D. L. Klingman, and R. E. Larson, U.S.D.A., University of Missouri, Columbia, Missouri . . 43
Control of Deep-Rooted Perennial Weeds with 2, 4-D-Boron Complexes and Other Soil Sterilizing Chemicals
W. M. Phillips, U.S.D.A. and Kansas Agricultural Experiment Station, Manhattan, Kansas 44
The Effect of Various Formulations of MCP and 2, 4-D on Weeds in Grain Crops
H. A. Friesen, Department of Agriculture Experiment Station, Lacombe, Alberta 46
The Control of Weeds in Alaska Field Crops with Dinitro Sprays
R. J. Bula, Alaska Agricultural Experiment Station, Palmer, Alaska 52
Comparing Ground and Air Application of 2, 4-D on Wheat
Russel L. Nash, Keith E. Wallace, and Lyle A. Derscheid, South Dakota State College, College Station, South Dakota 54

Section I Perennial Weed Control: (Wednesday Afternoon) Chairman: Lyle A. Derscheid

Soil Applications of 2, 4-D for the Control of the Deep-Rooted Perennial Weeds
Neal E. Schafer, University of Nebraska, Lincoln, Nebraska 56

The Effects of 2, 4-D and MCP on Sorghum
W. M. Phillips, U.S.D.A. and Kansas Agricultural Experiment Station, Manhattan, Kansas 59

Dalapon and Maleic Hydrazide for Control of Quackgrass
K. P. Buchholtz, University of Wisconsin, Madison, Wisconsin 62

Dalapon for Quackgrass Control
Paul W. Santelmann, University of Maryland, College Park, Maryland and C. J. Willard, Ohio State University and Agricultural Experiment Station, Columbus, Ohio 63

Chemical and Cultural Control of Field Bindweed on the High Plains of Texas
Allen F. Wiese and H. E. Rea, Texas Agricultural Experiment Station, Amarillo, Texas 64

Some Laboratory and Field Tests of Broadcast Nozzle Sprayers
L. A. Liljedahl, U.S.D.A. and John Strait, University of Minnesota, St. Paul, Minnesota 65

Section II Horticultural Crops: (All Day Wednesday) Chairman: Robert E. Nylund

Weed Control in Onions with CIPC
G. F. Warren, Purdue University, Agricultural Experiment Station, Lafayette, Indiana 71

Combinations of Chemicals for Weed Control in Onions
B. H. Grigsby and S. K. Ries, Michigan State College, East Lansing, Michigan 72

Field Studies with a New Class of Herbicidal Chemicals
L. H. Hannah, Monsanto Chemical Co., St. Louis, Missouri 73

Chemical Weeding of Onions
E. K. Alban, Ohio Agricultural Experiment Station, Columbus, Ohio 75

Weed Control in Potatoes by Pre-Emergence Sprays
B. H. Grigsby and Mark G. Wiltse, Michigan State College, East Lansing, Michigan 76

Weeding Asparagus with Chemicals
E. K. Alban, Ohio Agricultural Experiment Station, Columbus, Ohio 77

Post-Emergence Application of Herbicides on Tomatoes
S. K. Ries and B. H. Grigsby, Michigan State College, East Lansing, Michigan 79

Some Environmental Factors Which Influence the Use of DNBP with Sweet Corn, Lima and Snap Beans
E. K. Alban, Ohio Agricultural Experiment Station, Columbus, Ohio 80

Control of Quackgrass in Vegetable Gardens
Orrin C. Turnquist, University of Minnesota, St. Paul, Minnesota 81

Chemical Weed Control in Vineyards
D. D. Hemphill, University of Missouri, Columbia, Missouri 82

Weed Control in Apple and Cherry Orchards
LeRoy Holm and Franklin A. Gilbert, University of Wisconsin, Madison, Wisconsin 83

Chemical Weed Control in Taxus
L. C. Chadwick and P. A. Barker, Ohio Agricultural Experiment Station, Wooster, Ohio 84

Chemical Control in Deciduous and Evergreen Nursery Stock
L. C. Chadwick and P. A. Barker, Ohio Agricultural Experiment Station, Wooster, Ohio 86

Some Effects of Alanap (NP) and Amizol on Germinating Peas
B. H. Grigsby, Te May Tsou and G. B. Wilson, Michigan Agricultural Experiment Station, East Lansing, Michigan 88

Section III Woody Plant Control Research: (Wednesday Morning) Chairman: Dayton L. Klingman

A Progress Report on Field Experiences with Silvex
L. L. Coulter and J. W. Gibson, Dow Chemical Co., Midland, Michigan 90
Aerial Applications of Herbicides on Oak in Oklahoma
Harry M. Elwell, W. C. Elder, Dayton C. Klingman, and R. E. Larson, respectively, Red Plains Conservation Experiment Station, Guthrie, Oklahoma; Oklahoma A. and M. College, Stillwater, Oklahoma; U.S.D.A., Columbia, Missouri 91
Interim Report on Shinnery Oak Control Studies in the Southern Great Plains
E. H. McIlvain, U. S. Southern Great Plains Field Station, Woodward, Oklahoma 95
Chemical Eradication of Hawthorn
C. B. Owens, Florida A. and M. College, Tallahassee, Florida and C. J. Willard, Ohio Agricultural Experiment Station, Columbus, Ohio 96
Report of a Study of Brush Control Methods and Equipment
J. D. Crumpacker, University of Missouri, Columbia, Missouri and R. E. Larson, U.S.D.A., Columbia, Missouri 97
Some Effects of Basal and Frill Treatments of 2, 4, 5-T, Ammate, and CMU on Oaks
S. Clark Martin, and T. W. Jones, Central States Forest Experiment Station, Columbia, Missouri 99
Basal Sprays and Injection Treatments on Trees
L. S. Gleason and W. E. Loomis, Iowa State College, Ames, Iowa 102

Section III Control of Vegetation on Non-Crop Land Including Rights-of-way and Forested Areas: (Wednesday Afternoon) Chairman: Dayton L. Klingman

Mechanical Considerations for Control of Woody Plants
Walter E. Dietsch, Jefferson Proving Ground, North Vernon, Indiana 104
Brush Control - Materials and Methods
W. J. Coffey, American Telephone and Telegraph Co., Kansas City, Missouri 106
Comments on Effect of Common Brush Control Methods Used on Rights-of-way on Kill of Brush and on Game Food and Cover
R. Kauffmann, Asplundh Tree Expert Co.; R. H. Beatty and W. W. Allen, American Chemical Paint Co., Ambler Pennsylvania. (Manuscript not received)
Possibilities of Aerial Spraying in Forest Management in the Lake States
Eugene I. Roe, Lake States Experiment Station, St. Paul, Minnesota 109
The Control of Local Spread of Oak Wilt and Certain Other Tree Diseases with Herbicides
J. E. Kuntz, C. R. Drake and A. J. Riker, University of Wisconsin, Madison, Wisconsin 112

Urea Herbicides for Oak Control
Harry M. Elwell, U.S.D.A., Guthrie, Oklahoma 113
Control of Weed and Grass Competition in Forest Plantations
J. E. Kuntz and A. J. Riker, University of Wisconsin, Madison, Wisconsin 116
Chemical Weed Control in Shelterbelts
E. K. Ferrell, South Dakota State College, College Station, South Dakota 117

Wednesday Evening, December 8, 1954

"Magic and Weeds", Philosopher-Magician Claude O. Ebling, Soo Line Railroad. Exhibit Hall (Courtesy of Industrial Membership)

Thursday, December 9, 1954

Farmers' Day Program: Chairman: R. B. Widdifield

Development in Weed Control - Panel Chairman: H. E. Wood

2, 4-D or MCP for Weed Control in Flax, Oats, and Legumes
R. S. Dunham, University of Minnesota, St. Paul, Minnesota 119
Perennial Weed Control
Lyle Derscheid, South Dakota Agricultural Experiment Station, College Station, South Dakota 120
Wild Oats Control
H. E. Wood, Manitoba Dept. of Agriculture, Winnipeg, Canada 122
Chemical Control of Wild Oats
E. A. Helgeson, North Dakota Agricultural College, Fargo, North Dakota 123
Effect of Mustard in Wheat and Flax
L. H. Shebeski, University of Manitoba, Winnipeg, Canada 124
Use of Chemicals in a Practical Weed Control Program
E. P. Sylwester, Extension Service, Iowa State College, Ames, Iowa 125
Precautions in the Use of Weed Chemicals
L. H. Smith, Cottonwood County Weed and Seed Inspector, Windom, Minnesota 127
Promising Chemicals Being Tested
Dayton L. Klingman, Field Crops Research Branch, USDA, Columbia, Missouri 128

Weed Control on the Farm - Panel Chairman: E. H. Jensen

Wild Oat Control on My Farm
P. P. Dunn, Oakbank, Manitoba 131
Canadian Thistle Control
Ralph Diehl, Hillsboro, North Dakota 132
Weed Control on the Farm
Walter Trende, Rosholt, South Dakota 132
Weed Control on the Farm
Frank L. Mitchell, Canby, Minnesota 133
Sheep Pick Wild Oats from Flax Crop
Wm. R. Page, Grand Forks, North Dakota 134

Committee Reports:

Regulatory 135

Research 135

Terminology 149

Essay Contest 151

Resolutions 152

Registration List 153

List of Commercial Organization Members 161

List of Exhibitors 162

OPENING REMARKS

Oliver C. Lee 1/

Welcome to the 11th Annual North Central Weed Control Conference. It is a pleasure to see so many of you here. There are many familiar faces indicating that many of you have attended previous conferences. There are others I am sure who are attending for the first time. I understand that we have an unusually large representation from Canada. To them we, the North Central Conference, issue a special welcome. We are glad to have you here and sincerely hope you will feel at home and that you have a good visit and that the time spent here may be really worth your while.

It has been my good fortune to attend all of the 10 previous conferences. To me these conferences and the North Central Weed Control organization is the backbone of organized weed control. It has given all of us an opportunity to contribute and receive first hand information so necessary to promote the welfare of the profession of weed control. And indeed, weed control has become a profession in the last 10 or 12 years. It has made it possible for research agencies of the United States Department of Agriculture, the various university Experiment Stations and industry to coordinate their results and findings. The state Departments of Agriculture in charge of action programs, the teaching agencies of the Universities and those in industry charged with promotional work have taken this information out and put it to use, with the result of better weed control and much time saved on the part of the farmer and home owner. Not only farmers and homeowners, but utility companies, railroads, highway and many industrial firms have been aided by the program.

Regardless of amount of progress that we can point to, there is still much to do. If we in this profession of weed control are to keep up with the rapid progress taking place in other endeavors, we must stay on our toes. Not only is the job of weed control becoming more and more technical but it is expanding to cover many areas that were not classified under weed control before. I sometimes think we should change the title "weed control" to "vegetation control".

Nevertheless, we should all be on the lookout for ways and means of promoting interest in weed control. There is plenty of work to be done in research, education and weed law enforcement. If anyone questions the need for more adequate weed control we need only to point out the losses caused by weeds, some $5,000,000,000 annually in the United States. Further our economists tell us that by 1975 our population may reach to nearly 200 million people. When that time comes we cannot have weeds growing where food plants should be growing. It is our job, it is a challenge to us to see that infestations of weeds do not prevent an adequate food supply for that population.

It has been calculated that one hundred years ago it took a farmer five hours to produce a bushel of corn. Following World War 1, he had cut that time to 21 minutes, and today the modern corn belt farmer does the same job in 4 minutes. I think we in weed control work can take credit for a part of that time saving. Certainly modern weed control practices have helped to accomplish this feat.

It has been a pleasure to serve as President of this organization this year. I am honored to be asked to do so. The job has not been difficult because I have had such good help. Not a single person when asked to serve on a committee or to do a job has refused to do so. With such willingness and cooperation, it is easy to get the job done.

It is my hope that this conference may be as successful as those held in the past. In planning the program the committee found it necessary to resort to more sectional meetings than we have had before. Sectional meetings are objectionable from the standpoint that we cannot attend all sections at once. They make it possible however for more complete coverage of the various phases of weed control. Much of the program this time consists of volunteer papers. This I believe desirable from the standpoint of giving an individual an opportunity to speak his piece, so we can share in his findings and beliefs.

Your suggestions are always welcome. I hope you will make your wants and desires known. Your officers and directors will be happy to have suggestions for future meetings and for the organization as a whole. Let's have as our motto "A Bigger and Better Conference".

1/ Purdue University, Lafayette, Indiana

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THE WEED RESEARCH PROGRAM OF THE U. S. DEPARTMENT OF AGRICULTURE

M. W. Parker 1/

It is indeed a privilege to be asked to address the opening assembly of the 11th Annual North Central Weed Control Conference. In reviewing the past proceedings of this Conference, one can find much of the history of the developement of weed control work in the United States, and you should all feel proud for the part you and your Conference have played in bringing the research findings of this new discipline to the American farmer. At your first meeting, which was held on November 16 and 17, 1944 at Omaha, Nebraska, there were 90 registrants. Research, regulatory, extension, and commercial representatives of 20 states and Canada were present, and I recommend review of these proceedings for any one who becomes impatient with the progress that has been made in the past 11 years. Dr. M. A. McCall, then Head of the Division of Cereal Crops and Diseases, and Assistant Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, gave the banquet address, "A General Look at the Weed Problem". Many of the weed problems which he discussed that evening are still with us, but I was also glad to note that several of his predictions for the future have been realized. Dr. McCall referred to the advent of growth regulating substances which, in infinitesimally small amounts, would control plant growth. In 1954, it is estimated that over 85 million pounds of herbicides were used for weed control on agricultural and non-agricultural lands in the United States -- so, I think you will agree that this prediction of things to come has been realized.

The closing sentence of Dr. McCall's remarks is still most appropriate -- "Fact-finding, education, and application make up our collective job in defeating the weed menace."

As a newcomer to the field of weed research, I have enjoyed the opportunity of reviewing and evaluating the work which has been accomplished and to speculate as to the future. With the rapid development of weed control work during the past 10 years we may have been forced into a pattern of operation that may need to be re-examined. Progress in the future will be more difficult as the weed problems become more demanding for specificity, and there will be an increased need for adequate coordination of effort.

The Association of Regional Weed Control Conferences has done an excellent job of coordinating, and they have provided us with a journal for research papers on weed control. They have organized necessary committees, such as the Terminology Committee, which will benefit all segments of the weed control endeavor. They were also responsible for the arrangements for the first national weed control conference which was held last year. The Association has grown into national importance, but we are still asking two representatives from each regional conference to carry this burden. I believe it is time to re-examine this situation in light of the importance of weed control practices in our national agricultural economy.

Weed control work in the United States Department of Agriculture had its origin as a project in the Division of Cereal Crops and Diseases in 1935. Mr. L. W. Kephart was the first Project Leader and with him were Mr. F. L. Timmons, Jack E. Evans, L. M. Stahler, and Clarence I. Seely. With the exception of the late Jack Evans, all of these men are still in weed research. In 1950, the work had expanded sufficiently to warrant administrative reorganization and a new division was formed and announced at the 6th Annual Meeting of the North Central Weed Control Conference at Sioux Falls, South Dakota by Dr. R. M. Salter, then Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Dr. Roy L. Lovvorn was appointed Head of this new Division, and under his guidance, the Division grew from a few individuals to an organization of national scope.

In the reorganization of the Department of Agriculture, various functions have been assigned to three Assistant Secretaries. The broad areas of responsibility are Federal-States relations, Marketing and Foreign Agriculture, and Agricultural Stabilization. The Agricultural Research Service is one of the services included under Federal-States relations. This function of the Department is now headed by Assistant Secretary E. L. Peterson, who recently succeeded Mr. J. Earl Coke, and also includes Forest Service, Soil Conservation Service, Federal Extension Service, Agricultural Conservation Service, and Farmer Cooperative Service. The Agricultural Research Service, with Dr. B. T. Shaw as Administrator, has an Assistant Administrator for the Office of Experiment Stations, an Assistant Administrator for Management, a Deputy Administrator for Research, and a Deputy Administrator for regulatory work. Dr. George W. Irwin, the Depuyty Administrator for Research, has five research activities within his unit. Each of these is headed by a Director. Dr. A. H. Moseman is Director for Crops Research, which includes the Field Crops Research Branch, Horticulture Crops Research Branch, and the Entomology Research Branch.

The Weed Investigations Section is in the Field Crops Research Branch and Dr. Martin G. Weiss is Chief of this Branch. The Weed Investigations Section is headquartered at the Plant Industry Station, Beltsville, Maryland. The work of the Section is organized into four regional units -- the Western Region includes Washington, Oregon, California, Nevada, Arizona, Utah, Colorado, New Mexico, Idaho, Wyoming, and Montana. Mr. F. L. Timmons is the Western Regional Coordinator with headquarters at Laramie, Wyoming. At the present time we have men stationed at Washington, Oregon, Idaho, Montana, Wyoming, California, Nevada, Utah, and Arizona. In the North Central Region, which includes North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Illinois, Wisconsin, Michigan, Indiana, and Ohio, regional headquarters have been established at Columbia, Missouri and Dr. Dayton L. Klingman is Regional Coordinator. We have men stationed in five states -- North Dakota, Nebraska, Kansas, Missouri, and Michigan.

In the Southern Region, which includes Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Tennessee, Kentucky, and Virginia, we have at the present time, men stationed in Oklahoma, Texas, Arkansas, Louisiana, Mississippi, Georgia, and North Carolina. Regional headquarters for the Southern Region is at State College, Mississippi and Dr. William B. Ennis, Jr. serves as Regional Coordinator. In the Northeastern Region, which includes all of the New England states, New York, Pennsylvania, New Jersey, Maryland, and West Virginia, we have only one man, outside of the Beltsville group, at the present time. Dr. Richard J. Aldrich is stationed at New Brunswick, New Jersey and acts as our Regional Coordinator for this region.

We would like very much to strengthen our work in the Northeastern Region and plan to do so as soon as possible. At our headquarters at Beltsville, Maryland we have a total of four professional employees. Dr. Warren C. Shaw is in charge of our work on the evaluation of chemicals as herbicides, Dr. Charles R. Swanson is coordinating our work on physiology, and Mr. Paul J. Linder is doing work with Dr. Shaw on the relation of chemical volatility to the devopment and use of herbicides. In the future we plan to increase both our technical and administrative staff at Beltsville. Project leaders are needed to coordinate our research work on weed control in cultivated crops on irrigated and non-irrigated lands, and on our program of weed and brush control on pasture and rangelands.

At the present time, there are 36 professional employees in the Weed Investigations Section. Twenty-three of these men are stationed at State Agricultural Experiment Stations and are working on cooperative projects. In addition to this cooperative effort, 39 chemical companies have cooperated with us on our program on the evaluation of new chemicals for possible herbicidal value.

We realize that our program is only one segment of a multiple attack which includes state activities, industrial activities, and equipment manufacturers. It is only through such cooperative effort that we will continue to make the progress that we have in the past 10 years.

During the past summer I have had an opportunity to visit each of the 36 technicians which we have at the present time, and I believe that you would be interested in hearing some of the highlights of our field program.

The research program of the Section is organized into 13 line projects. They are concerned with research on (1) weeds in field crops; (2) weeds in horticulture crops; (3) weeds on grasslands and range; (4) weeds associated with irrigation farming; (5) weeds in fiber crops; (6) control of woody plants; (7) physiological mechanisms involved in selectivity; (8) the ecological requirements of weeds and crops; (9) the evaluation of chemical herbicides; and (10) soil sterilants.

In the North Central Region, we have here at Fargo, Mr. Robert N. Andersen who is working on weed control in sugar beets. Wild oat infestations continue to be a major problem in sugar beets, but pre-planting treatments in which the herbicide is disced into the soil some time before planting shows promise. Combinations of herbicides such as TCA and Endothal, TCA and PCP as pre-emergence and post-emergence herbicides, under some conditions, have given satisfactory weed control.

At Lincoln, Nebraska we are working on weed control in pastures. This long-term project was started in 1949 by Dr. Dayton L. Klingman and much fundamental ecological information on the effects of 2, 4-D on the composition of pastures has been obtained. Mr. M. K. McCarty is continuing this work, and has expanded and initiated new studies on the effects of herbicides on the botanical composition of pastures.

At Hays, Kansas, Mr. William M. Phillips is engaged in a cooperative project on the control of weeds in sorghum, pre-harvest weed control and crop drying of alfalfa, and control of bur ragweed and field bindweed. In the latter study, he is evaluating new soil sterilants for their effectiveness in controlling these weeds.

Drs. Dayton L. Klingman and O. Hale Fletchall at Columbia, Missouri are working on weed control problems associated with field crops and grasslands. They have worked with soybeans, corn, and other crops and have combined cultivation with chemical treatments in order to determine the efficiency of both methods of controlling weeds in these crops. Their work on grassland weeds has included studies for the control of ironweed; selective control of lance-leaved ragweed from a bluegrass-lespedeza pasture; selective control of weedy grasses and broad-leaved weeds in legume seedlings; and a screening test for selective nimblewill control in bluegrass sod. They are also working on the control of woody plants with Mr. Russel E. Larson of the Agricultural Engineering Research Branch.

Time will not permit a detailed accounting of our work in the other three regions; therefore, I will simply point out the major activities in various subdivisions of the regions.

In the Western States, we are studying weed control problems that are associated with irrigated agriculture. The tolerance of crops to herbicides mixed with the irrigation water becomes most important because aquatic weeds in the canals must be controlled as well as the usual crop land weeds. There are large areas devoted to dry-land wheat farming surrounding some of the irrigated areas, and the aerial application of 2, 4-D to the dry-land wheat has made it important to determine other crop tolerances to 2, 4-D since drift is known to occur. We are also working on the control of Canada thistle and other perennial weeds that infest cereal crops in this area.

In the inter-mountain area, our major emphasis at the present time is on studies designed to develop methods for the control of halogeton. We are studying the ecology, physiology, and life-cycle of this plant in our effort to develop satisfactory control methods. This work is being conducted in close cooperation with the inter-mountain states, the Bureau of Land Management, the Bureau of Reclamation, the Forest Service and other agencies interested in this problem.

We have recently increased our staff in California so that we may expand our work on weed control in irrigated cotton. This work involves both field and laboratory studies on problems associated with this type of cotton production. We also have work in Arizona on weed control in irrigated cotton, but the two areas have different weed problems.

In the Southwest, various types of brush have steadily encroached on many acres of rangeland and reduced the desirable forage species. This brush can be controlled by the proper use of herbicides, and we have studies in Arizona, Texas, and Oklahoma in an attempt to improve methods now in use and to investigate new techniques for woody plant control.

Weeds in rice have become more of a problem with the restrictions on the use of 2, 4-D in areas where sensitive crops are grown in close proximity. Annual grasses not controlled by 2, 4-D have also become a serious problem. Studies on weed control in rice at Stuttgart, Arkansas and Biggs, California are being initiated to expand our weed control investigations on this crop.

In the Southeast, our principal emphasis has been on weed control in cotton. This work involves close cooperation with the agricultural engineers and much progress has been made. Over 300, 000 acres of cotton were treated with pre-emergence herbicides last year and we expect the practice to continue to increase. New chemicals and new control techniques are being evaluated continuously in an effort to improve current practices. We also are doing research on weed control in peanuts, corn, soybeans, and other crops grown in the South, as well as research on the control of weeds and brush on grasslands, and the control of hardwood species in pine forests used for grazing.

In the Northeastern Region, our major emphasis has been on studies designed to control weeds in vegetable, fruit, and field crops. Dr. Aldrich at New Jersey has given particular attention to the regional factors affecting the efficiency of pre-emergence sprays. His studies have involved a comparison of the relationships between the effectiveness of cultivation and chemical treatments and combinations of cultural and chemical practices. Satisfactory chemical weed control practices have been developed in potatoes, beans, asparagus, strawberries, alfalfa, and other field and horticultural crops.

We have established projects to study the fundamental physiological mechanisms involved in the toxic action of herbicides on plants at Raleigh, North Carolina, Tucson, Arizona, College Station, Texas, and Davis, California. We plan to expand and strengthen this type of work whenever possible.

The research program at Beltsville, Maryland consists of 4 projects; (1) evaluation of new chemicals as herbicides; (2) a study of the relation between structure and activity; (3) physiological studies on the mechanisms of herbicidal activity; and (4) the absorption and translocation of herbicides in plants.

The project on the evaluation and development of new herbicides is under Dr. Warren C. Shaw and the primary objectives of this work is to supply our field men and our cooperators with preliminary data on promising new chemicals for specific weed control problems. The most promising chemicals from our Beltsville evaluation project are then tested at several field locations so that response under many different environmental conditions can be determined. When these results are evaluated, we can then make further suggestions as to chemicals of potential value as herbicides. This procedure has resulted in eliminating unnecessary duplication of primary herbicide evaluation studies within our Section.

At present, our work on this project is directed toward a systematic study of families of compounds or related compounds to determine the relation between molecular structure and herbicidal activity. Industry has supplied most of the chemicals for this work. Their willingness to cooperate with both Federal and State research agencies has unquestionably been one of the greatest assets to the rapid advancements that have been made in the past.

Dr. Charles R. Swanson is in charge of our projects which involve physiological studies on the mechanisms of herbicidal activity. At the present time, he is studying respiration processes as affected by herbicidal treatments and the mechanism of chlorophyll synthesis as influenced by several herbicides. In addition to these studies, Dr. Swanson will coordinate the physiological weed research within the Section.

We hope that the Weed Investigations Section will continue to grow so that we can strengthen our existing program and expand our efforts into areas inadequately covered at the present time. This cannot be accomplished overnight and I doubt that it would be wise if such expansion were possible. Our plans for the future seek an orderly expansion so that the most pressing problems can be given adequate attention.

In 1952, 33.5 million acres were sprayed for weed and brush control. In the same year the combined acreage sprayed and dusted for disease and insect control was about 20 million acres. It is almost unbelievable that the use of chemicals for weed control could have advanced so rapidly.

In 1952, approximately 18 million acres of small grains (wheat, oats, rye, barley, flax, and rice), 9.5 million acres of corn, 2.5 million acres of pasture and rangeland, and over 3.5 million acres of other crops were sprayed for weed control.

About 70 percent of the acreage sprayed and dusted for weed control in 1952 was treated by the farmer using his own equipment. The cost of materials on this acreage amounted to about 26 million dollars. On the remaining 30 percent of the total acreage, custom operators furnished and applied the herbicides for a total charge of about 22 million dollars. These costs do not include materials and application costs for the control of weeds on non-agricultural lands.

It is estimated that 15 percent of the total acreage, or over 5,000,000 acres of cropland was sprayed for weed control in 1952 using aerial equipment at about an average cost of 2 dollars per acre to the farmer. Thus it may be seen that the aerial application of herbicides for selective weed control has developed into at least a 10 million dollar business annually in a period of less than six years.

With ever-increasing interest in weed and brush control on pasture and rangelands, we need more fundamental research in this field. This sould cover basic research dealing with the physiological mechanism involved in selectivity and a critical evaluation of factors affecting the efficiency of herbicides. Fundamental agronomic studies to determine how chemical methods can most effectively be used in our cropping practices and the long-term effects of herbicides on soil should be continuously reviewed and expanded as needed.

We also need to increase our efforts on weed control in horticultural crops. This is a difficult field since most of the crops are produced for human consumption and that elusive thing of quality and taste preference is ever present along with possible health hazards.

To be more specific as to areas that should receive more attention in the future, I would like to point out a few of the spots which we think need strengthening at the present time. One of the first that has come to my attention is the role that environment plays in relation to herbicidal action. Canada thistle plants growing in wheat plots at Saint Anthony, Idaho respond quite differently to 2,4-D than Canada thistle in similar plots at Bozeman, Montana -- a distance of approximately 120 miles. Is this difference in response due to temperature, rainfall, or soil, or to a combination of these environmental factors, or are we studying an entirely different species? We need to study such problems and the only way that satisfactory answers can be obtained is through the use of controlled environment equipment. This equipment need not be the most elaborate or the most costly to produce answers to this most important question.

The mode of action of herbicides is another most important field that has not received adequate attention. How does a herbicide kill one plant that we classify as a weed and let the other plant which we classify as desirable continue to live? We call this selectivity, but what is the physiological basis for this selectivity? We can vaguely refer to the herbicidal action on the enzyme system, the respiratory mechanism, or the carbohydrate-nitrogen metabolism, but are any of these effects responsible for the killing action or the selectivity? These questions and others must be answered if we are to continue our progress in this field.

Another area in which basic information seems to be limited concerns life-cycle studies on plants classified as weeds. What factors control germination of weed seed? Are there specific temperature or light requirements, and how long will the seed remain dormant? Does the germinated seed remain in the seedling stage for a long or short period, and when does the grand period of growth occur? Surely this information should be obtained on all the plants which we hope to control by either chemical or cultural methods. We have all noted the ecological changes that have resulted from the use of herbicides to control weeds in crop plants. Ecological research has a very important place in any weed control program.

All of you who have been trying to find new people for your weed programs will agree with me that one of our most serious problems at the present time is the lack of well trained personnel for this type of work. This problem would be resolved if we could prescribe the type of training that a weed research man should have, and would make these requirements known to the colleges and universities that are not already offering such curriculum in one of their departments. We are a highly specialized group and certainly there is little likelihood that this

complexity will decrease in the future. Consider the disciplines required for a good, well trained weed research man. He should have a sound agronomic or horticultural background, which would include soils. In addition, knowledge of specific desciplines such as chemistry, botany, mathematics, physics, physiology, morphology, taxonomy, ecology, etc., is required for specialized positions. We are asking for a lot, but I believe that many students would be interested in devoting their efforts to this field if its potential was brought to their attention more forcefully.

The ultimate goal of all agricultural research is to help the farmer produce more food or fiber in a more economical manner. The recommendations which you develop for weed control practices must get back to the farmer. There are established channels in the State and Federal extension programs for this service but unfortunately, in 1953 there were less than 6 full-time State extension weed specialists in the United States and no full-time Federal extension weed specialists. We must strengthen this field if we are to aid farmers in adopting the technological advances that we have developed in this fast moving field.

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EFFECT OF VARIOUS WEED INFESTATIONS ON THE GROWTH AND YIELD OF SOYBEANS

D. W. Staniforth and C. R. Weber 1/

(Abstract)

Effects on bean yields of: amount of infestation in the row, species involved, length of time the weeds remained in competition with the beans, and stages of growth of soybeans at which weeds were removed, were investigated over a three-year period. Yellow foxtail (Setaria lutescens) and either Polygonum pennsylvanicum, or Abutilon theophrasti, were grown as separate infestations and removed at each of six stages of soybean growth, ranging from seedling to maturity. Weed infested soybeans were also defoliated to simulate hail injury, and effects of subsequent weed competition studied.

As measured by bean yields, competition between weeds in the row and bean plants began early at the 3 to 4 trifoliate leaf stage, and persisted to maturity at approximately the same level. Yield losses in undefoliated beans averaged ten percent or less, at the various stages of growth, with infestations of 6 and 12 grass plants or 3 and 6 broadleaved weed species per foot of row. Bean yield depression was more than twice as great in a favorable year as compared to a very dry season. Foxtail caused greater bean yield losses than broadleaved species. In terms of total plant material produced per acre, weeds and soybeans grown together yielded as much as weed-free soybeans.

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RATE OF LEACHING AND BREAKDOWN OF SEVERAL HERBICIDES IN DIFFERENT SOILS

G. F. Warren 1/

The increasing use of herbicides that have a residual effect when applied to the soil has made it necessary to determine the movement and breakdown pattern of these chemicals in different soil types. The probable length of time the herbicide will be effective in killing weeds, the possible danger to succeeding crops, and the likelihood of pre-emergence applications moving to the crop seed represent some of the important information that can be gained from these studies.

In the experiments reported here an attempt was made to shorten and modify the methods reported by Ogle and Warren (1) so that the relative breakdown and leaching behavior of herbicides could be determined rapidly. Studies were conducted on four soil types, namely, a fine sand, silt loam, "old" muck and "new" muck. The fine sand and silt loam contained 1.0 and 3.5 per cent organic matter respectively while the muck soils were of organic origin. The "old" muck had been farmed for many years and was in a finely divided state while the "new" muck had been farmed only one year and was coarse and fibrous in nature. Activity of the herbicides following treatment was determined biologically by obtaining the fresh weight of crabgrass 14 to 18 days after planting 50 seeds.

For leaching studies, soil in cellophane columns was saturated one day, treated the next, leached with two inches of water on the third and sliced into one inch sections and planted with crabgrass on the fourth day. The activity was measured at the 0, 1, 2, and 4 inch depths as well as in the surface of treated but unleached soil. For breakdown studies the herbicides were mixed with the soil and kept moist by sub-irrigation in a warm greenhouse. Crabgrass was planted to measure activity at 0, 2, 4 and 8 weeks.

In the leaching experiments, CMU and 3-(3, 4-dichlorophenyl)-1, 1-dimethyl urea (DCMU) were used at the rate of 2 pounds per acre. The amine salt of MCP and the amine salts and propylene glycol butyl ether esters of 2, 4-D, 2, 4, 5-T and 2(2, 4, 5-trichlorophenoxy) propionic acid (Silvex) were applied at 4 pounds of acid equivalent per acre. CIPC, TCA (sodium salt), dichloral urea, sodium 2, 2-dichloropropionate (Dalapon) and the sodium ethyl sulfate forms of 2, 4-D (SES) and 2, 4, 5-T (Natrin) were all applied at an 8-pound rate. DNBP (amine salt) and PCP (sodium salt) were used at 16 and 32 pounds respectively. In the breakdown studies the same quantities were used on the mineral soils but the rates were doubled on the mucks.

The herbicides showed many decidely different patterns of leaching which varied with soil type. The pattern of movement appeared to be influenced both by the strength of absorption of the herbicide by the soil and by relative solubility in water. Two chemicals, the sodium salts of TCA and Dalapon, were absorbed to a minor extent if at all since they leached readily and showed the same pattern in all four soils. All of the other weed killers were apparently absorbed to some extent since they moved less in the silt loam and muck soils than in the fine sand. In general these herbicides showed greatest movement in the sandy soil and progressively less in the silt loam, "new" muck and "old" muck.

The chemicals studied are grouped below according to their relative movement following leaching:

Moved readily in all soils tested:

TCA	Dalapon

Moved readily in the mineral soils but showed some resistance to movement in mucks:

2, 4-D, amine	MCP, amine
SES	DNBP, amine
Dichloral urea	

Moved considerably in the sandy soil but little or none in the others:

2, 4-D, ester	Natrin
2, 4, 5-T, amine	Silvex, amine

Resistant to leaching in all soils, showing some movement only in the sand:

2, 4, 5-T, ester	PCP, sodium salt
Silvex, ester	CMU

Highly resistant to leaching:

DCMU	CIPC

The rate of breakdown of the herbicides was influenced by soil type and, in general, residual life in the soil tended to be longest in the sand and progressively less in the silt loam, "new" muck and "old" muck. The results of this study are summarized below:

Activity gone in two weeks

Sand	Silt Loam	New Muck	Old Muck
Dalapon	Dalapon	Dalapon	2, 4-D, amine
2, 4-D, amine	2, 4-D, amine	2, 4-D, amine	2, 4-D, ester
2, 4-D, ester	2, 4-D, ester	2, 4-D, ester	SES
SES	SES	SES	2, 4, -T, amine
	CIPC	PCP	2, 4, 5-T ester
			CIPC
			PCP

Activity present at two weeks but gone after four weeks

Sand	Silt Loam	New Muck	Old Muck
TCA	TCA	TCA	Dalapon
Dichloral urea	Dichloral urea	Dichloral urea	TCA
CIPC	2, 4, 5-T, amine	2, 4, 5-T, amine	Dichloral urea
	2, 4, 5-T, ester	2, 4, 5-T, ester	Natrin
	PCP	CIPC	CMU
			DCMU

Activity at four weeks but not at eight

Sand	Silt Loam	New Muck	Old Muck
PCP	Silvex, amine	DNBP	Silvex, amine
2, 4, 5-T, amine	Silvex, ester	Natrin	DNBP
Silvex, amine		Silvex, amine	
Natrin		Silvex, ester	
DNBP		DCMU	

Activity at eight weeks

Sand	Silt Loam	New Muck	Old Muck
2, 4, 5-T, ester	Natrin	CMU	Silvex, ester
Silvex, ester	DNBP		
CMU	CMU		
DCMU	DCMU		

These studies show the widely varying patterns of leaching and breakdown that occur with different herbicides and the strong interaction with soil type. It is suggested that such information should be obtained for new herbicides having residual activity in the soil before they are extensively tested in the field.

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1/ Purdue University, Lafayette, Indiana

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A NEW SETARIA SPECIES IN ILLINOIS

F. W. Slife 1/

There are some 60 species of Setaria in the world. Twenty-eight of them are native to North America, and 18 of the 28 are native to the United States. Although the genus is made up of both annual and perennial plants, the annuals are the most troublesome weeds.

Yellow foxtail (Setaria lutescens) and green foxtail (Setaria viridis) were both introduced from Europe. They were described in detail by Linnaeus in 1753 as well as by subsequent botanists. As in most taxonomic literature, the genus and species have been changed several times. They were named Setaria, later called Chaetochloa and still later renamed Setaria. Many of the species were classified as Panicum and some others as Pennisetum (pearl millet).

Green and yellow foxtail were among the first species described by botanists of the colonial period. They apparently spread westward and have established themselves as two of our most serious annual grass weeds in the northern United States and Canada. These two species are among the first annual plants to germinate in the spring.

The seriousness of grass weeds has long been known, but attention has been focused on them during the last few years because, after the continued use of 2, 4-D to remove broadleaf weeds, the grasses are becoming more serious.

In the corn-belt area of the United States, 3 species of Setaria are particularly troublesome. They are yellow foxtail (S. lutescens), green foxtail (S. viridis) and giant foxtail (S. faberii). Although giant foxtail is a relatively new weed in our area, it was described as early as 1910. During the course of investigations on giant foxtail in 1950, another annual species of foxtail was noted. It was brought to our attention in fields by the fact that it usually had purple awns and occasionally purple pigment in the foliage. At that time it was assumed it was Setaria italica, which also grows wild in our area. A more detailed study of this plant follows.

It is an erect growing annual commonly reaching six feet in height and occasionally seven, if undisturbed. Morphologically, it is similar to S. viridis except in vigor. This greater height is accounted for by the fact it has on an average of four to five nodes per plant. The seed size and markings on the seed coat are similar to S. viridis. The shape of the panicle and the degree of bending of the panicle in the field is similar to S. viridis. Although the shape of the panicle is similar, the new species has a much larger panicle. It contains approximately 4000 seeds while S. viridis contains approximately 800.

In comparing this new species with S. italica, it was found that the seed size was smaller than any of the common varieties of cultivated millet. The point of disarticulation of the seed is used in separating S. italica from S. viridis. In S. italica, the seed disarticulates above the glumes while in S. viridis the site of disarticulation is below the glumes. In the new species, the disarticulation occurs below the glumes, indicating it is similar to S. viridis.

There is a distinct possibility that this new species could be a hybrid. It has the size and vigor that often results in a hybrid. In checking the chromosome number, it appears to have 18 as the normal complement. This is the same as S. viridis and S. italica.

S. lutescens and S. faberii both have 36 as the normal chromosome complement. Therefore, if it is a cross, it seems more likely that it would have to be between S. italica and S. viridis. Besides having the vigor of a hybrid, it has the characteristics of a recent cross in that it is extremely variable. There is considerable variation in color and in degree of lobing in the panicle. The seed size in all of these types, however, seems to be uniform.

Crosses between S. italica and S. viridis apparently have not occurred in the past even though there are records of S. italica culture as early as 2700 B. C. However, Li, et al (1) reported that it was possible to cross these two species and some of the F_2 plants he obtained seem similar in appearance to the material we are studying.

It should be reported that Pohl (2) has possibly encountered the same type of plant in that he states, "occasionally found in stands of green foxtail are tall, vigorous, broadleaf forms with large panicles, resembling millet."

This new type of foxtail has not as yet been named, but the appearance of this plant in many areas in Illinois during the past few years indicates that it could become a serious weed problem. It apparently produces over twice as much seed per plant as giant foxtail (S. faberii) and it seems to persist in cultivated areas the same as giant foxtail.

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EFFECT OF BORATE ADDITIVES ON HERBICIDAL QUALITIES OF 2,4-D

J. D. Stone & D. W. Rake 1/

(Abstract)

This report is primarily concerned with investigations on control of micro-organic activity in the soil. These studies deal with ways and means of improving and extending the desirable action of organic pesticides through the use of additives to prevent or buffer the biological chemical or physical reaction which limit the activity of organic herbicides in the soil.

Early laboratory studies showed that compounds such as 2,4-D are readily utilized as nutrients by microorganisms occurring naturally in the soil and that growth of these organisms may be actually accelerated by additions of 2,4-D within certain limits. Standard potato nutrient agar media, to which 2,4-D was added at rates of 0.075 lbs., 0.150 lbs. and 0.300 lbs. equivalent per 100 sq. ft., was inoculated with a water infusion from fresh garden soil and incubated for 7 days. The growth of soil microorganisms was accelerated in proportion to the added increments of 2,4-D, with the lowest rate used being approximately equivalent to 33 lbs. of the herbicidal material per acre.

Numerous tests were undertaken to determine the practicability of adding to the pesticidal compound, in formulation or application, an ingredient that would depress, limit or prevent the growth or activity of microorganisms that feed on, or decompose these organic pesticidal compounds.

For practical field application, such an additive must be cheap, readily available, adaptable to water spray, or dry application and must have chemical and physical characteristics compatible with the physical, chemical and end use characteristic of a wide range of the pesticides of interest.

The sodium salt of 2,4-D was selected as a standard test material representing the organic pesticides and among the additives tested as possible microorganism control agents were pentachlorophenol and its salts, or sodium or calcium borate salts. Initial tests with these materials indicated their effectiveness in reducing the activity of the soil-born organisms and at the same time, illustrated economy from a possible use viewpoint. Disagreeable handling characteristics and limited periods of effectiveness discouraged continued study of the pentachlorophenol compounds. The sodium borates, having desirable herbicidal characteristics, were thoroughly investigated.

Agar plates were treated with 1 lb. per 100 sq. ft. equivalent and 2 lbs. per 100 sq. ft. equivalent of a 2,4-D acid 7.5%/sodium borate 92.5% mixture. The culture media was inoculated with a soil water infusion and incubated for 7 days. Also included in this test were the equivalents of the individual constituents making up the complex along with representative check plates. Microorganic activity was completely inhibited on the cultures treated with the 2,4-D borate complex and with the borate additives alone.

Additional proof of the microorganic activity depression exhibited by this mixture of 2, 4-D and sodium borates was obtained by determining the relative activity of the soil organisms on the basis of CO_2 evolution as measured in mm of mercury pressure by use of a simple mercury monometer. Treatments of 0. 150 lbs. 2, 4-D acid equivalent per 100 sq. ft. showed micro-activity to be high and uniform throughout the 7 day incubation period and varied from 2. 40 mm of mercury to 3. 82 mm of mercury. The borate/2, 4-D complex showed a range of 0. 05 to 0. 23 mm mercury pressure while the check ranged from 2. 90 to 4. 40 mm of mercury pressure.

The next step in this investigation involved the testing of selected compositions in the greenhouse. In initial pot tests the soil was added to the container, brought to field moisture levels; oat and mustard seeds planted and the herbicidal compounds added to the soil surface and leached in by sprinkling sufficiently to maintain good growing conditions. The herbicidal treatments consisted of a complex of 7. 5% 2, 4-D acid equivalent combined with 92. 5% of a selected sodium borate and applied at 1 lb. per 100 sq. ft. and 2 lbs. per 100 sq. ft. The equivalents of the individual constituents were also included in these tests.

The plants were grown for 30 days with plant counts and growth determinations made at regular intervals. At the end of this period water was withheld to kill any remaining plants and without further addition of the herbicidal compounds a second and third planting was made to determine the residual herbicidal qualities of the compositions. Each of these successive plantings were grown for 30 days.

All treatments were effective in inhibiting the growth of mustard throughout the three successive plantings. Oat growth was markedly depressed throughout this period and was directly proportional to the treatments of the individual constituents of borax and 2, 4-D respectively, with the greatest depression exhibited by the combination of these two components.

At the end of the 70 days or the middle of the third successive planting, plots receiving 1 lb. per 100 sq. ft. of the borate/2, 4-D complex showed 30% stand of oats and 30% growth vigor; whereas, the 2 lb. rate per 100 sq. ft. of the complex showed 15% stand 10% growth vigor. At the end of this third successive planting, or 90 day growing period, all plants were dead on the plot receiving the 2 lb. per 100 sq. ft. treatment and less than 10% survival evident on the 1 lb. per 100 sq. ft. treatment.

The individual constituents of borax and 2, 4-D equivalents at the 1 lb. per 100 sq. ft. rate showed only 8% and 52% reduction of stand, respectively, at the end of the 90 day test period.

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RESPONSE OF RUSSIAN THISTLE TO 2, 4-D AND ADDITIVE NUTRIENT ELEMENTS

J. J. Sexsmith 1/

As a result of the introduction of "additive" or "fortified" 2, 4-D dust, to be sold in preference to the ordinary 2, 4-D spray or dust materials because of their possible added advantage of foliar fertilization, tests with the dusts have been under way at the Lethbridge Station since 1951. Thinking that it would be of value to the western farmer, in consideration of the much greater use of 2, 4-D in the spray form, some tests were put out in 1952 using major and minor fertilizer elements in aqueous sprays, with and without 2, 4-D amine on weed infested spring wheat, and with 2, 4-D amine on weed infested flax. The somewhat startling results from certain of the applications led to a further small test in 1952, and an expanded program in 1953 and 1954. Due to an unfortunate set of circumstances the 1954 tests were of little value. In general, some of the 1953 findings with major element additions were substantiated, but nothing further on the effects of minor element additions was determined.

1952 Tests

The major fertilizer elements used in 1952 were obtained by the use of commercial fertilizer materials and the minor elements (iron, copper, and cobalt) by the use of appropriate analytical grade chemicals.

None of the foliar applications of several major and minor elements, either alone or in combination, and with or without 2, 4-D, had any effect on wheat yield when applied to wheat in the early shot-blade stage of growth.

The addition of mixed fertilizers, supplying from 2 1/2 ounces to 10 pounds of nitrogen, from 11 ounces to 20 pounds of phosphorus, and 6 pounds to 10 pounds of potassium per acre, did not change the effectiveness of the 6 acid ounce amine 2, 4-D spray against stinkweed (Thlaspiarvense). However, the addition of 0. 7 pound iron, 0. 7 pound copper, or 0. 35 pound cobalt per acre (obtained from sulphate salts), alone or in combination, lowered the effectiveness of the 2, 4-D against stinkweed.

In the flax test, the flax was up to 12 inches tall and nearly to the bud stage when treated, at which time the heavy infestation of Russian thistle (Salsola pestifer) was mostly up to 8 inches tall with four or more well formed branches.

The results of the applications of 2, 4-D amine to which had been added the elements listed above, may be summarized as follows: all of the fertilizer additions (including N, N and P, or N, P and K) increased the effectiveness of the 2, 4-D amine against Russian thistle, whereas the addition of the iron, copper and cobalt salts decreased the effectiveness of the 2, 4-D applications. Further, the treatments which gave enhanced weed control were also more damaging to the flax crop, as indicated by a slight decrease in the height of the flax and an increase in the time taken to reach maturity. The copper sulphate addition lessened the time to maturity by three or four days as compared with the 2, 4-D amine treatment. Because of the generally poor flax stand, yield samples were not taken.

A small test was put out later in the 1952 season on second crop Russian thistle, growing in a thin stand of volunteer barley, to find the relative effectiveness of ammonium phosphate (11-48-0) and organic nitrogen

(urea) additions to a 5 acid ounce 2, 4-D amine spray at varying levels of nitrogen additions, and also the effect of iron, copper, and cobalt salt additions with and without ammonium phosphate. At the time of application on August 1st, the thistles were from 3 to 8 inches tall with from four to eight well developed branches, and were considered to be resistant to the 5 acid ounce dose of 2, 4-D amine.

Urea, at rates ranging from 2 1/2 ounces to 10 pounds nitrogen supplied per acre, did not change the herbicidal effectiveness of the 2, 4-D amine. Ammonium phosphate increased the effectiveness of 2, 4-D amine against the Russian thistle, but there was no apparent difference between additions supplying 2 1/2 ounces or 2 pounds of nitrogen per acre. The further addition of iron, iron plus copper, copper plus cobalt, or iron plus copper plus cobalt (at rates mentioned above for the wheat test) to an ammonium phosphate - 2, 4-D amine solution did not alter the increased effectiveness of the mixture.

1953 Tests

Analytical grade chemicals were used for all major and minor plant food element additions in the 1953 tests. Treatments were applied at a solution rate of 11.7 gallons per acre in 1953 as compared with a rate of 67.8 gallons in 1952.

In the spring wheat test, the major and minor element materials were applied both with and without 2, 4-D. None of the treatments caused visible injury to the wheat, and the control of Russian thistle obtained from treatments containing 2, 4-D was essentially of the same order as was obtained in the flax test.

The flax plots were treated when the flax was 18 to 20 inches tall in bloom to the half-formed boll stage, and the medium heavy infestation of Russian thistle consisted of plants from 6 to 8 inches tall with 10 to 12 well formed branches. The additions to a 4 acid ounce rate of 2, 4-D amine were compared with a water sprayed check, 2, 4-D amine at 4 ounces, and 2, 4-D ester at 2 and 4 ounces per acre.

As was to be expected, 2, 4-D amine at 4 ounces was inferior to an equal rate of 2, 4-D ester for the control of Russian thistle. Additions of ammonium phosphate, ammonium sulphate, potassium phosphate, ammonium nitrate, and ortho phosphoric acid increased the herbicidal value of the 4 ounce 2, 4-D amine to a point equal to or better than that obtained with the 4 ounce 2, 4-D ester treatment. The addition of ammonium potassium phosphate and of urea increased the effects of the 2, 4-D amine, but to a lesser degree.

The effect of the various additions mentioned above were, with possible one exception, essentially equal for either the 2 ounces of nitrogen and/or 2.2 ounces of phosphorus or the 8 ounces of nitrogen and/or 8.8 ounces of phosphorus. The exception was found in the ammonium nitrate addition for which the higher rate of addition resulted in slightly better control of the Russian thistle, and the same degree of difference was also noted in the wheat test. It would appear that perhaps the nitrate nitrogen is less effective than the ammonium nitrogen, or that the nitrate nitrogen has no value or is of negative value for increasing the degree of control of Russian thistle obtained with 2, 4-D amine. Further, it would seem that the lowest rate of effective addition of nitrogen in the ammonium form is between 1 and 2 ounces of nitrogen per acre, because the 2 ounces of nitrogen from ammonium sulphate or ammonium phosphate was of more value than the 2 ounces of nitrogen from ammonium nitrate, of which only one ounce was supplied by the ammonium group.

The addition of phosphorus and nitrogen (from ammonium group) to 2, 4-D seems to be of no more value than the addition of ammonium nitrogen alone. The addition of phosphorus, in either the acid or salt form, increased the effects of 2, 4-D, but not as much as did ammonium nitrogen. Potassium additions, with either nitrogen or nitrogen and phosphorus, were of little or no value, and there was some indication that the potassium lessened the effectiveness of the other additions.

Iron and copper additions, in either the nitrate or sulphate form, lessened the effects of the 2, 4-D amine against Russian thistle.

The general effect of the late application of effective additions to 2, 4-D amine was a curling down of the Russian thistle. Such a curl-down would give a possibility of harvesting flax without inclusion of a mass of Russian thistle material. From a practical standpoint, even if late treatment with additions were to cause some reduction in flax yield, the harvest might be more economical and less difficult, and the total returns greater than if no herbicidal treatment had been applied.

Data were obtained for the effects of treatments on flax maturity and flax seed yields. The flax stand was relatively poor, and as a result not too much faith can be placed in yield results. However, the yields obtained were such that general trends were indicated.

Treatments which had given an increased degree of Russian thistle control also had delayed the maturity date of the flax by approximately one week, and given yield reductions of from three to five bushels per acre. It is interesting to note that even though the higher rate of phosphoric acid addition caused a delay in maturity, the delay was several days less than that resulting from the other effective additions.

Discussion and Summary

1. Some form of nutrient element addition to 2, 4-D amine sprays possibly can be of use for a better control of the more resistant weed species. The accompanying increase in injury to the crop is less in spring wheat than in flax.

2. For weed control in flax, the use of additions might be of value in a season when a delay occurred in weed seed germination and subsequent growth. Under such circumstances, the additions would provide for greater ease of harvest, and a good recovery of a better quality crop.

3. Ammonium salts at minimum rates of nitrogen addition (2 ounces per acre) to 2, 4-D amine gave best results. The organic from of nitrogen was less effective. Additions of iron, copper, and cobalt salts (nitrates and sulphates) by themselves, were of no apparent value for enhancing weed control. However, there was some evidence that the addition of a copper salt may tend to lessen the maturity delay to flax resulting from 2, 4-D plus N or 2, 4-D plus P applications.

4. Phosphorous additions helped to increase the effectiveness of the 2, 4-D amine against Russian thistle but were not as good as the ammonium nitrogen additions

at approximately the same rates. The inclusion of potassium, along with nitrogen and phosphorus in 2,4-D amine sprays, was of no apparent value.

5. Further work is needed to find the element or combination of elements that may increase the herbicidal effects of a given rate of 2,4-D without causing undue injury to the crop. It is possible that some additions may give the added advantage of an increase in crop quality and quantity.

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EFFECTS OF HERBICIDES ON MITOCHONDRIAL ENZYME SYSTEMS 1/

C. M. Switzer 2/

Many herbicides induce changes in the respiration of treated plants. In recent years evidence has accumulated that the enzymes involved in aerobic respiration are located in discrete cytoplasmic particles called mitochondria (5). Each mitochondrion apparently contains the entire complement of enzymes and coenzymes necessary for the total oxidation of pyruvate and other intermediates of the Krebs cycle to CO_2 and water. Such oxidations may be carried out in vitro by properly isolated mitochondria (5).

This paper is a preliminary report on an investigation of the effects of various herbicides on O_2 uptake and CO_2 evolution of systems containing isolated soybean mitochondria. The technique of isolation was essentially that of Millerd et al. (5). Etiolated soybean hypocotyls were ground in a phosphate-sucrose solution, filtered to remove cell wall fragments, and the mitochondria separated from the filtrate by differential centrifugation. After washing, the mitochondria were resuspended in phosphate-sucrose solution and added to the reaction mixture under study. Gas measurements were made with a Warburg respirometer, and each flask contained mitochondria, pyruvate or succinate as substrate, phosphate, sucrose, A.T.P., magnesium, herbicide and/or water to a total volume of 3 ml.

The data of Table 1 show that O_2 uptake and CO_2 evolution by isolated mitochondria with pyruvate as substrate were inhibited more than 50% by 2×10^{-3} M 2,4-D (460 ppm) and only slightly affected by 10^{-3} M (230 ppm). Inhibition of O_2 uptake by intact pea and oat seedlings has been shown by Kelly and Avery (4) at concentrations of 2,4-D from 500 to 1000 ppm, although sprays at 1000 ppm have been shown to increase the respiration of intact bean, bindweed and dandelion plants (1). With pyruvate as substrate, 10^{-4} M 2,4-D (23 ppm) increased O_2 uptake, but 10^{-5}M had no effect. A much wider stimulatory range has been demonstrated with whole plant tissue by numerous investigators. Pea seedling showed stimulation from 0.0001 ppm up to 100 ppm, and oat seedlings from 0.1 ppm to 200 ppm (4). Dow (3), working with lupine mitochondria, found inhibition of O_2 uptake by 10^{-4} M 2,4-D with pyruvate or succinate as substrates, but obtained stimulation when citrate was used.

Table 1. Effect of 2,4-D on O_2 uptake and CO_2 evolution by soybean mitochondria. Data are the average of 3 experiments.

2,4-D Molarity	Pyruvate O_2, % control	Pyruvate CO_2, % control	Succinate O_2, % control
10^{-2}	7.5	25.2	
5×10^{-3}	23.9	32.2	
4×10^{-3}	10.6	15.4	
3×10^{-3}	20.5	52.4	
2×10^{-3}	44.1	73.9	
10^{-3}	97.6	91.5	65.2
10^{-4}	113.4	91.1	96.5
10^{-5}	94.4	100.1	100.0
10^{-6}	104.8	90.7	105.0

The effects of spraying plants with 2,4-D before extraction of the mitochondria upon subsequent gas exchange by the mitochondrial system were studied, for comparison with the direct effects of the chemical. Etiolated soybean plants were sprayed with 100 ppm 2,4-D 24 hours before extraction of the mitochondria. This concentration of growth regulator brought about pronounced curvature of the hypocotyls, swelling, and increased turgidity. Mitochondria isolated from these plants had decreased O_2 uptake when either succinate or pyruvate was used as substrate, but increased CO_2 evolution when pyruvate was used. Since mitochondria treated in vitro with concentrations higher than 100 ppm showed little effect, it would appear that the aerobic system is more sensitive to 2,4-D when treated in vivo.

Table 2. Effect of spraying etiolated soybeans with 100 ppm 2,4-D, 24 hours before harvest, on respiration of soybean mitochondria. Average of 3 experiments.

Substrate	O_2 uptake, % control	CO_2 evolution, % control
Succinate	89.4	88.5
Pyruvate	75.0	114.0

TCA at concentrations higher than 5×10^{-2} M (9400 ppm) inhibited both succinate and pyruvate respiration more than 50% (Table 3). Concentrations from 10^{-2} M to 10^{-6} M (1880 ppm to 0.188 ppm) slightly increased O_2 uptake in the presence of pyruvate. Similar stimulation in this range was obtained by Kelly and Avery (4) with Avena coleoptile tissue. The inhibition at the higher concentrations was probably brought about by the action of TCA as a protein precipitant.

Table 3. Effect of TCA on O_2 uptake and CO_2 evolution by soybean mitochondria. Data are the average of 3 experiments.

TCA	Pyruvate		Succinate
Molarity	0_2, % control	$C0^2$, % control	0^2, % control
10^{-1}	9.2	96.5	15.3
5×10^{-2}	50.0	88.0	30.0
10^{-2}	111.0	103.4	84.3
10^{-3}	113.0	97.3	96.4
10^{-4}	100.3	75.4	71.0
10^{-5}	104.5	98.8	93.8
10^{-6}	107.0	85.3	91.2

Indoleacetic acid (IAA) inhibited succinate respiration at a concentration of 10^{-3} M (175 ppm) and had little effect at lower concentrations down to 10^{-9} M (0.0002 ppm) (Table 4). This is in marked contrast to the consistent stimulation of respiration of plant tissue brought about by concentrations of IAA from 0.0001 ppm to 1.0 ppm (2). Dow (3) also found inhibition of lupine mitochondria respiration at 10^{-2} M and 10^{-3} M IAA, but obtained a slight stimulation at 10^{-4} M.

Table 4. Effect of IAA on 0_2 uptake by soybean mitochondria with succinate as substrate. Data are the average of 4 experiments.

IAA, Molarity	0_2 uptake, % control
10^{-3}	77.5
10^{-4}	96.9
10^{-5}	92.7
10^{-6}	99.7
10^{-7}	105.0
10^{-8}	100.5
10^{-9}	105.7

$NaC10_3$ inhibited pyruvate respiration 20 - 30% at concentrations above 5×10^{-2} M (0.88% or 8800ppm), whereas concentrations of 10^{-3} to 10^{-6} M increased 0_2 uptake. With succinate as substrate, 0_2 uptake was inhibited 20% by 10^{-1} M $NaC10_3$ and not significantly affected by lower concentrations. $C0_2$ evolution, in contrast, appeared to be rather strongly depressed, even at low concentrations. Chlorate has been assumed to act upon respiratory processes in the plant, but these results offer no simple clue to the mechanisms involved.

Table 5. Effect of $NaC10_3$ on 0_2 uptake and $C0_2$ evolution by soybean mitochondria with succinate or pyruvate as substrate. Data are the average of 4 experiments.

$NaC10_3$	Pyruvate		Succinate	
Molarity	0_2, % control	$C0_2$, % control	0_2, % control	$C0_2$, % control
10^{-1}	79.1	108.2	80.2	58.9
5×10^{-2}	72.4	105.3	94.2	57.6
10^{-2}	102.5	107.6	96.8	89.2
10^{-3}	115.3	113.3	97.6	70.1
10^{-4}	111.6	111.9	90.4	76.6
10^{-5}	112.5	—	92.7	84.6
10^{-6}	115.0	—	—	—

Experiments in which an herbicidal oil (Standard L-8764) was added to the reaction mixture with or without a wetting agent, showed that both 0_2 uptake and $C0_2$ evolution were strongly inhibited by the oil alone. Greater inhibition was obtained when a wetting agent was added to the oil, but the wetting agent used alone inhibited respiration as much as the oil plus wetting agent, probably because of disorganization of the lipid fraction of the mitochondria by the wetting agent. It is difficult to compare these results with those obtained by other investigators using intact plants because of the relatively large quantities of oil used in the flasks.

Table 6. Effect of a herbicidal oil (Standard L-8764) and a wetting agent (B-1956) on 0_2 uptake and $C0_2$ evolution by soybean mitochondria, with pyruvate as substrate. Data are the average of 4 experiments.

Treatment	0_2 uptake, % control	$C0_2$ evolution, % control
L-8764, 1.6%	50.3	37.8
L-8764, 3.3%	59.7	86.9
L-8764, 6.6%	47.5	81.0
L-8764, 1.6% +1.6% B-1956	30.2	18.5
L-8764, 3.3% +1.6% B-1956	22.5	53.2
L-8764, 6.6% +1.6% B-1956	25.6	61.9
B-1956, 1.6%	32.5	46.3
B-1956, 3.3%	16.5	41.0

Preliminary experiments with Dalapon indicate that this chemical will inhibit pyruvate respiration at concentrations higher than 10^{-4} M (16.5 ppm) but that it has little effect on succinate respiration up to 10^{-2} M (1650 ppm). These results suggest a specific effect of Dalapon on some early step in the Krebs cycle.

Our experiments with mitochondria so far indicate that the observed effects of herbicides on respiration of treated plants are not due to changes brought about in the pyruvate or succinate oxidase systems. Inhibition of respiration in vitro is shown by all chemicals, but requires such high concentrations that a general action rather than a specific blocking of activity is suggested. Stimulatory effects, which may be marked in plants, are small or absent in the mitochondrial systems under study. Dalapon may be an exception to these generalizations and its reactions will be studied in detail. The possibility of direct effects on other phases of aerobic respiration than those thus far studied, or on glycolysis, should be investigated. Even more likely, herbicides may indirectly affect respiration through changes in coupled reactions such as phosphlorylation.

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ON THE KINETICS OF INHIBITION OF GROWTH BY HERBICIDES 1/

R. E. Frans and E. F. Lind 2/

If it is possible to express growth or inhibition of growth as a mathematical function of the concentration of applied herbicides, such an expression may be useful in characterizing and comparing different herbicides. Information obtained by the use of single herbicides may also be helpful in predicting growth responses to mixtures of herbicides. This investigation represents an attempt at assessing the growth response of soybean seedlings to varying herbicide concentrations.

Methods and Materials

Soybean seedlings were grown in the greenhouse in four-inch pots with three plants in each pot. Treatments were made when the primary leaves were fully expanded, but while the first trifoliate leaf was still rolled in the bud. Aqueous solutions of herbicides of varying concentrations were applied uniformly to the plant foliage by means of a modified De Vilbiss paint spray gun. The plants were sprayed on a turntable rotating at 78 r. p. m. to insure uniformity of application. Eight replications were used in a randomized block design. Growth was measured as the fresh weight of all plant material above the primary leaves, 10 to 14 days after treatment (2). The data thus obtained were converted to percentage inhibition of growth relative to the controls.

Results and Discussion

A plot of the percentage inhibition against the concentration of each of the several herbicides tested described a hyperbolic relationship between the two variables (Fig. 1).

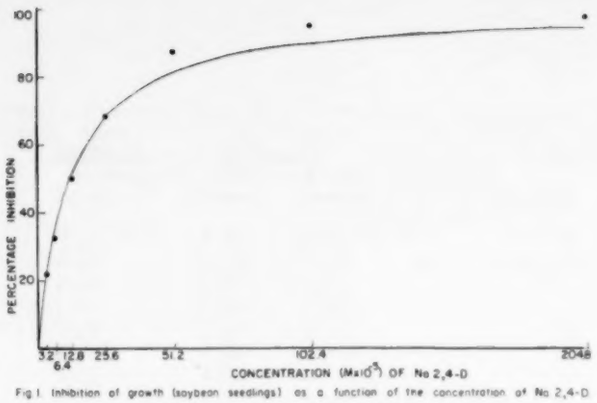

Fig. 1. Inhibition of growth (soybean seedlings) as a function of the concentration of No 2,4-D. The solid line represents the hyperbola described by equation 1. The points represent experimental determinations. Growth was measured by increase of fresh weights.

An attempt was made to apply a generalized Michaelis-Menten (5) hypothesis to the action of the herbicides, namely:

$$H + M \underset{2}{\overset{1}{\rightleftharpoons}} HM \xrightarrow{3} \text{Inhibition of growth}$$

where M indicates a mechanism or compound with which H, the herbicide, combines reversibly (reactions 1 and 2). It is further proposed that inhibition results from an irreversible reaction proceeding with a rate proportional to the concentration of HM (reaction 3). Burton (1) has shown that this irreversible reaction would not have to be the only reaction, or the last one in a sequence leading to inhibition, in order to be the rate determining step.

A kinetic treatment of the above system yields:

$$v = \frac{V_{max}\ [H]}{K_m + [H]} \qquad (1)$$

where v designates the rate of inhibition, K_m the equilibrium constant of the reversible reaction, V_{max} the rate of inhibition when all M-sites have combined with the herbicide, and [H] is the molar concentration of the herbicide. Rewritten in analogy with the Lineweaver and Burk treatment (3), equation 1 becomes:

$$\frac{1}{v} = \frac{1}{V_{max}} + \frac{K_m}{V_{max}} \cdot \frac{1}{[H]} \qquad (2)$$

A straight line should be obtained when the inverse of the percentage inhibition (1/v) is plotted against the inverse value of the molar concentration (1/[H]) if the generalized Michaelis-Menten hypothesis can be applied. The constant K_m/V_{max}, is the slope of this line and the constant $1/V_{max}$ represents the intercept of the line on the 1/v axis.

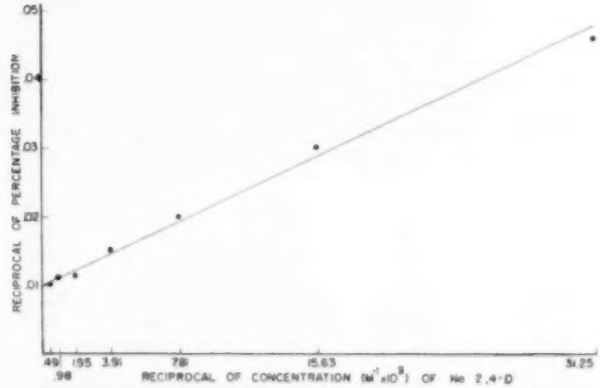

Fig. 2. The reciprocal of inhibition of growth (soybean seedlings) as a function of the reciprocal of concentration of No 2,4-D. Calculation of linear regression yielded these values for the constants: $V_{max} \times 10^2$, $K_m \times 1.18 \times 10^{-4}$

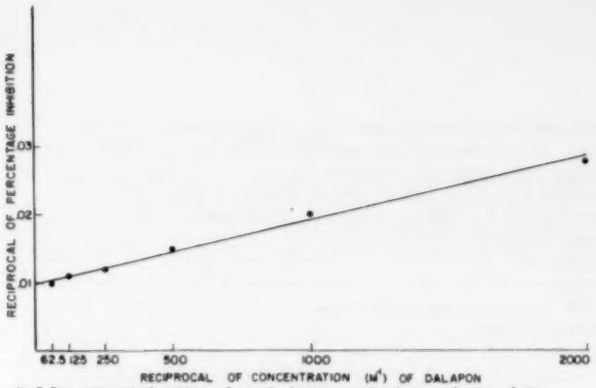

Fig.3 The reciprocal of inhibition of growth (soybean seedlings) as a function of the reciprocal of concentration of Dalapon. Calculation of linear regression yielded these values for the constants: $V_{max} = 10^2$; $K_m = 9.28 \times 10^{-4}$.

Figs. 2 and 3 show the relationships between percentage inhibition and the concentrations of sodium 2, 4-dichlorophenoxyacetate (2, 4-D) and sodium 2, 2-dichloropropionate (Dalapon). The straight lines in these doubly reciprocal plots were fitted to the experimental points by calculation of linear regressions. When the constants obtained from the intercepts and slopes of these lines are substituted in equation 1, theoretical hyperbolic curves for straight arithmetic plots of percentage inhibition against concentration are the result. A typical hyperbolic curve is shown in Fig. 1. The experimentally determined points show a rather good agreement with the theoretical curve.

The extension of this treatment to the action of mixtures of two herbicides was tried on admittedly inadequate data. However, a promising "trend" is reported, using essentially the approach of McRae, et al. (4), in which the inverse of the percentage inhibition is plotted against the inverse of the sum of the concentrations of the two herbicides, the ratio between the two concentrations being constant.

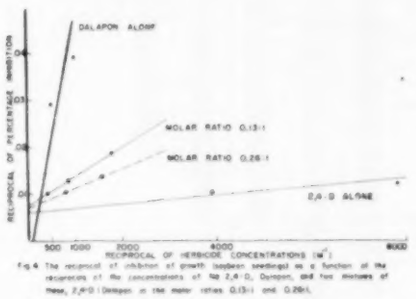

Fig.4 The reciprocal of inhibition of growth (soybean seedlings) as a function of the reciprocals of the concentrations of: No 2,4-D, Dalapon, and two mixtures of these, 2,4-D : Dalapon in the molar ratios 0.13:1 and 0.26:1.

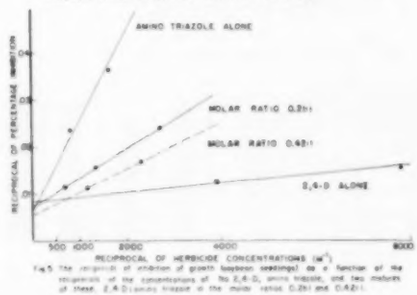

Fig.5 The reciprocals of inhibition of growth (soybean seedlings) as a function of the reciprocals of the concentrations of: No 2,4-D, amino triazole, and two mixtures of these, 2,4-D : amino triazole in the molar ratios 0.3:1 and 0.42:1.

Figs. 4 and 5 show the single responses and the response to mixtures of sodium 2, 4-D and Dalapon (Fig. 4), and of sodium 2, 4-D and 3-amino-1, 2, 4-trizole (amino triazole) (Fig. 5). A third point on each of the two straight lines representing the single herbicides could not be plotted conveniently on graphs of this size.

Two estimates of the combined constant K_m for a constant ratio between concentrations of two herbicides were obtained. One estimate of K_m (combined) was obtained by a calculation similar to that of McRae, et al. (4), considering V_{max} a constant (V_{max} = 100%). Another estimate was obtained by a determination of the slope of the straight line resulting when the inverse of the rate of inhibition was plotted against the inverse of the sum of the two concentrations. The two estimates of the K_m values for the 0.13:1 ratio of sodium 2, 4-D to Dalapon were 6.95×10^{-4} and 6.41×10^{-4}; for the 0.21:1 ratio of sodium 2, 4-D to amino triazole, they were 4.44×10^{-4} and 6.14×10^{-4}.

The results reported seem to support the generalized Michaelis-Menten hypothesis. Furthermore, the estimates of the "combined" equilibrium constants from the known values of the "single" equilibrium constants seem to make possible a prediction of the action of mixtures of herbicides. It is hoped that current and more extensive investigations will throw more light on the subject.

Summary

It is proposed that the hyperbolic relationship between inhibition of plant growth and herbicide concentrations may be analyzed in analogy with classical enzyme concepts. Thus, it has been shown that the doubly reciprocal plots of the above two variables result in a linear relationship over the investigated concentration ranges when certain herbicides are applied to soybean seedlings. The constants derived from such straight lines and substituted in equation 1, yield theoretical inhibition curves with which the experimentally determined points are in close agreement. It is further proposed that the knowledge of the constants derived from the response of plants to single compounds may allow the extension of this treatment to the prediction of behavior of plants to mixtures of herbicides.

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2/ Iowa State College, Ames, Iowa

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INFLUENCE OF RATES AND TIME OF APPLICATION AND TILLAGE PRACTICES ON RESIDUAL EFFECTS OF CMU 1/

Lowell Jordan and R . S. Dunham 2/

CMU, 3(p-chlorophenyl-1, 1-dimethylurea), is occupying a prominent place among chemicals used for complete vegetation control. One of the most important attributes of such an herbicide is its persistence in the soil. At the Rosemount Agricultural Experiment Station, trials were undertaken by the University of Minnesota to determine some factors that might affect the persistence and movement of CMU in the soil. A parallel study was made of the vegetative succession on the treated plots but it is not included in this paper.

Three factors were studied: rates of application, time of application, and fall or spring plowing vs. no tillage. The herbicide was applied to a quackgrass sod on Waukegan silt loam. Persistence of the chemical in toxic amounts was determined by the appearance of vegetation on the plot. The time lapse before vegetation reoccurence and the types of returning vegetation were studied.

Depth of penetration was ascertained in the greenhouse by a bioassay test. Soil plugs were taken from the plots at one inch levels through the top six inches. Additional six-inch plugs were taken from the 6 to 12 inch layer. The soil samples were placed in greenhouse pots and planted to oats or soybeans. The degree of injury was determined by any resulting necrosis in the test plants.

Rates varied from 5 to 80 pounds per acre. The period of sterility lengthened with increased rate of application. Both annual weeds and quackgrass reappeared on plots treated with 5 to 15 pounds per acre during the growing season following application. Plots receiving 20 pounds became reinfested during the second season and 30 to 80 pound plots remained sterile into the third growing season. With an increase in rates there was a relatively smaller proportion of quackgrass and a larger proportion of other species as vegetation returned. Rates above 20 pounds per acre were required to control quackgrass effectively. With an increase in rates there was also an increase in depth and rapidity of penetration of CMU into the soil. Depth of penetration after one year is shown in Figure 1. Deeper penetration is shown after two years in Figure 2 but depths and rates are still related.

To study the effect of time of application, plots were sprayed fall, spring and summer. Longer sterility and better quackgrass control resulted from fall and spring applications than from summer treatments. A study of Figure 3 shows that in the undisturbed soil receiving 10 pounds of CMU, the penetration was deeper from the fall application than the spring which was to be expected. But on plots receiving 15 pounds the reverse was true and depth in plots sprayed with 30 pounds was about the same for both fall and spring applications. Precipitation records for the area showed that where deeper penetration occurred on plots receiving the same rates, there had been heavier rainfall following application.

The effect of no plowing vs. fall plowing vs. spring plowing was also interesting especially when related to time of application. Penetration of CMU in undisturbed plots was considerably less than corresponding plowed plots. This probably accounts for better quackgrass control the first year on unplowed vs. plowed plots. An interesting result is illustrated in Figure 3 where spring plowed plots receiving fall applications even up to 30 pounds showed no residual toxicity to test plants in the greenhouse. Since there was little regrowth of quackgrass on these plots and considerable regrowth on the undisturbed and fall plowed plots, the reason for this greenhouse result is unknown.

At the close of the second year best control of quackgrass resulted on the plowed plots. Largest regrowth of annuals occurred on the fall-sprayed spring-plowed plots.

Fig. 1. Effect of rates of application and plowing vs no plowing on penetration of CMU into the soil. Samples taken 1 year after treatment.

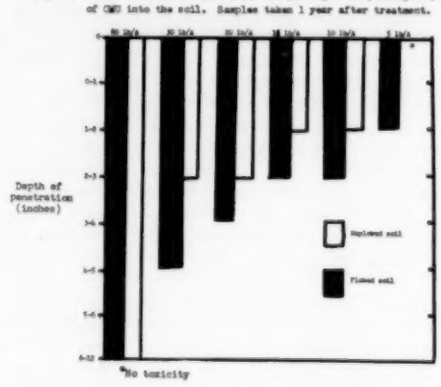


Fig. 2. Effect of rates of application and plowing vs no plowing on penetration of CMU into the soil. Samples taken 2 years after treatment.

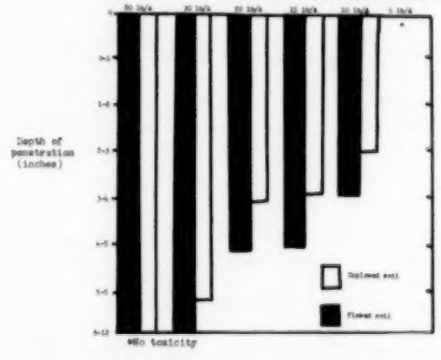
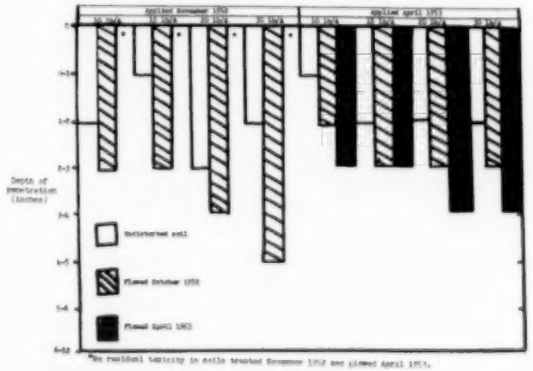


Fig. 3. Effect of time and rates of application and fall and spring plowing vs no plowing on penetration of CMU into the soil. Soil samples taken July 16, 1953.



*No residual toxicity in soils treated November 1952 and plowed April 1953.

Summary

(1) With increased rates there was (a) an extension of the period of sterility, (b) an increase in rapidity and depth of penetration, and (c) a relatively smaller proportion of quackgrass and a larger proportion of other species as vegetation returned.

(2) Longer sterility and better quackgrass control resulted from fall and spring applications than from summer applications. The depth and rapidity of penetration into the soil was related to the moisture conditions at and following the time of application.

(3) Applications on plowed ground gave better ultimate quackgrass control than on unplowed. Applications on unplowed ground gave better immediate control. CMU penetrated the plowed soil more rapidly than unplowed soils.

1/ Paper No. 3286 of the Scientific Journal Series, Minnesota Agricultural Experiment Station.

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FACTORS AFFECTING THE DISAPPEARANCE OF SUBSTITUTED UREA HERBICIDES IN AGRICULTURAL SOILS

G. D. Hill, J. W. McGahen, J. R. Haun and

V. L. Turner 1/

The compounds 3-(p-chlorophenyl)-1, 1-dimethylurea and 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea are used at low rates of application as pre-emergence herbicides on cotton, pineapple, sugarcane, and asparagus. When these materials are used for weed control in crops, it is important that the question of herbicidal residues in the soil be examined, particularly since these compounds are noted for their long-term vegetation control when applied at high rates such as 40 to 60 pounds per acre.

The rate of disappearance of these herbicides from soil was measured under field conditions over a two-year period in plots established on a Keyport silt loam at Newark, Delaware; on Cecil loamy sand at Raleigh, North Carolina; on Leon-Immokalee sand at Palma Sola, Florida; and on Lintonia silt loam at Essen Lane, Louisiana. Results from chemical analyses and the growth of cover crops indicate that when these herbicides are used annually for weed control in crops at rates of 1 to 2 pounds per acre 2/ phytotoxic concentrations disappear from the soil within four to eight months after each application. Annual applications result in no significant accumulation in the soil. Under the same conditions as above, it has been found that a 4-pound per acre application of these herbicides is reduced to innocuous levels in cultivated soils 12 to 16 months after initial application. When considerably higher amounts, 40 to 60 pounds per acre, are applied for plant sterilant use on non-cultivated soils, a phytotoxic concentration often remains in the soil for 24 to 36 months.

Factors involved in the disappearance of the substituted urea herbicides from soils were evaluated in the laboratory. These included leaching, volatilization, chemical decomposition and biological degradation.

In a lysimeter study, which included eleven soil types, 10 pounds per acre of 3-(p-chlorophenyl)-1, 1-dimethylurea was applied to the surface of the soil and the equivalent of 72 inches of rainfall was passed through the columns (36'' deep). With this extreme amount of leaching, some chemical was present in the leachate from seven of the eleven soils. None of the chemical was found in the leachate from the other four soils. Under field conditions, removal of 3-(p-chlorophenyl)-1, 1-dimethylurea and 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea from the soil by percolation is believed not to be a major factor, since after application of 1 to 2 pounds per acre the results of numerous soil analyses indicated that essentially no herbicide was present below a depth of 4 inches.

The most interesting result obtained from the lysimeter study was that after the 90-day leaching period, 38 to 85% of the 10-pound per acre application on the various soil types was unaccounted for either in the leachate or in the soil, indicating the possibility of microbiological degradation.

At 25°C, 3-(p-chlorophenyl)-1, 1-dimethylurea, a typical member of this group of herbicides, has a vapor pressure of 5×10^{-7} mm. Hg. in contrast to the isopropyl ester of 2, 4-D with a vapor pressure of 10.5×10^{-3} mm. Hg. (The substituted urea herbicide is approximately 20, 000 times less volatile.) In view of this extremely low vapor pressure at ordinary temperatures, loss of the compound from the soil by volatilization is likely to be a minor factor under field conditions, where rains would move the compound into the soil. Volatilization might be a significant factor where the herbicide is applied to the surface of dry soil and remains on the surface for extended periods during hot, dry weather.

Initial results from chemical decomposition studies in vitro indicate that hydrolysis or oxidation of the substituted urea compounds is slow at ordinary temperatures. However, photodecomposition may occur at a measurable rate. It was found that an 83% loss of 3-(p-chlorophenyl)-1, 1-dimethylurea occurred when a standard solution containing 88. 3 ppm in distilled water was sealed in quartz tubes and exposed to sunlight for 48 days. Thus, the action of light may be a positive factor in disappearance when there is little rainfall after application and the chemical remains on the surface of the soil.

It was shown that soil microorganisms play an important role in the decomposition of the substituted urea herbicides in soils:

(1) Treated samples of a Cecil loamy sand which were sterilized and stored for six weeks at 80°F and 65% relative humidity retained the initial phytotoxic effects of both herbicides, while treated samples stored under non-sterilized conditions showed a marked reduction in the phytotoxicity of both herbicides.

(2) In a similar type of experiment, non-sterilized samples of Cecil loamy sand and of Brookston silty clay loam were treated at 1 and 5 ppm, respectively, with 3-(p-chlorophenyl)-1, 1-dimethylurea and 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea and incubated for six weeks. These samples were retreated each time prior to 6 to 12, 12 to 18, and 18 to 22 weeks further incubation periods. By chemical analyses, it was found that there was approximately a 40% loss of both compounds in each soil during the 22 weeks of incubation at 80°F and 65% relative humidity.

(3) Radiolabeled 3-(p-chlorophenyl)-1, 1-dimethylurea with C^{14} in the methyl group was employed to determine the extent of breakdown of the structure by soil microorganisms. When 2 ppm of the labeled compound mixed with a clay loam was incubated at room temperature for 90 days, approximately 10% was decomposed, as measured by $C^{14}O_2$ evolution.

(4) In Warburg studies it was shown that soil microorganisms could utilize 3-(p-chlorophenyl)-1, 1-dimethylurea as the sole source of carbon.

Based on the results of the laboratory studies described above, it is concluded that the disappearance of these herbicides from cultivated soil can be attributed primarily to microbiological degradation, although other factors such as leaching, volatilization, and chemical decomposition may be contributing factors under certain conditions.

1/Grasselli Chemicals Dept., Experimental Station, E.I. duPont de Nemours & Co., Inc., Wilmington, Deleware

2/ All rates and concentrations are expressed on an active ingredient basis.

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THE CORRELATION OF STRUCTURE AND ACTIVITY FOR A NEW CLASS OF HERBICIDAL CHEMICALS

P. C. Hamm and A. J. Speziale 1/

Introduction

A new class of herbicides, derivatives of a-chloroacetamides, has been shown to possess outstanding effectiveness and selectivity, particularly for the control of annual grasses. Their activity with germinating grass seeds is comparable to 2, 4-D in broadleaf weed seed control.

The N-substituted and N, N-disubstituted derivatives of a-chloroacetamide which exhibit this selective phytotoxicity are prepared chemically as follows:

Fig. 1

$$R_2NH + ClC\text{-}CH_2Cl \longrightarrow R_2NC\text{-}CH_2Cl$$

A primary or secondary amine is allowed to react with chloroacetyl chloride in the presence of dilute sodium hydroxide and a solvent such as ethylene dichloride below 0^oC. The chloroacetamide is recovered from the solvent layer and purified by either distillation or recrystallization from an appropriate solvent. The yields are usually greater than 75%. Experimental details on methods of preparation will be reported elsewhere.

The herbicidal activity of the a-chloroacetamides and homologs has been correlated with respect to variations of the N-substituents and the acyl chain.

The study reported here is an attempt to acquaint workers in the field with: (1) the type of activity exhibited by this new class of compound, (2) the herbicidal specificity evident among plant species, (3) the herbicidal power of these chemicals and, (4) the relationship between structural configuration of the molecule and activity.

Materials and Methods

The results to be reported here are based largely on greenhouse screening studies. Our screening evaluation of these chemicals for pre-emergence herbicidal action is quite simple. The chemical to be tested is applied in spray form to soil seeded to representative grass and broadleaf plants.

An aluminum pan, 13" x 9" x 2", is level filled with a standard soil preparation. The soil surface is compacted to a depth of 3/8" from the pan top by means of a template tamper. Twenty seeds each of three weedy-grasses and five corn seeds are scattered randomly over one third the area of the soil surface. Twenty seeds each of five or six representative broadleaf plants are scattered on the remaining 2/3 of the soil area. The seeds are covered with soil to the pan top, a depth of 3/8". The planted pans are placed in an exhaust hood and sprayed first with 30 cc of an aqueous solution containing 1% Folium (Folium is the Monsanto trade name for a water soluble 20-20-20 fertilizer) and 0.1% OMPA (Octamethyl pyrophosphoramide). The Folium furnishes a uniform nutrition level and the OMPA prevents insect injury from our most prevalent pests, aphids and mites.

The pan is next sprayed with 30 cc of an organic solvent (usually acetone) containing the unknown chemical to be tested. The spray volume is kept constant; the rate per acre of active chemical is varied as desired.

For contact studies we employ the same aluminum pans, the same plants and planting procedure. The spray application is made at any desired time after emergence. A spray volume of 15 cc per pan is used. The solution concentration or rate per acre may be varied as desired.

Discussion

Type of Activity: The outstanding action of these new herbicides is inhibition of germination and growth of seeds and more particularly grass seeds.

This class of herbicide has shown most promise when used as a preemergence spray but is definitely not confined to this type of action. Good to excellent grass control has been achieved with several derivatives when used as a contact spray on weedy annual grasses.

The behavior pattern evidenced by these compounds differs from presently known herbicides in a number of ways: (1) There are distinct differences in plant species susceptibility or resistance. (2) They appear to work better in heavy soils and soils high in organic matter than they do in light sandy soils. Of primary importance is the herbicidal specificity exhibited.

Perhaps the most outstanding attribute of this class of chemicals is the ability to remove such things as crabgrass, foxtail, cheatgrass and wild oats from corn without injury to the corn. The safety factor is something like two to three times the recommended dosage needed to control the grasses indicated. While the a-Chloroacetamides would be classed generally as grass specific, they are not confined solely to grass control. Many common broadleaf weeds such as pigweed, carpet weed, prostrate spurge, and purslane are controlled well to very well.

Another point of primary interest is the herbicidal potency of these new chemicals. The activity can be expressed in two ways, for emphasis.

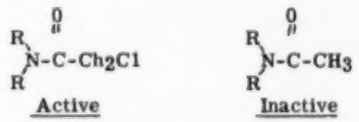
An empirical measure is obtained if seeds are germinated in aerated aqueous solutions containing the test chemical. As little as 0.025 ppm of certain a-Chloroacetamides is required for 80% growth inhibition of rye grass seed. Comparable results are obtained with 3-Chloro I. P. C. in this same test.

In more practical terms it appears that rates of two to eight pounds per acre will adequately control most annual grasses in the field.

The Relationship Between Structural Configuration and Activity: There are a number of well defined correlations between the structure and activity of these chemicals. These pertinent observations are perhaps best expressed by simple statements followed by specific examples.

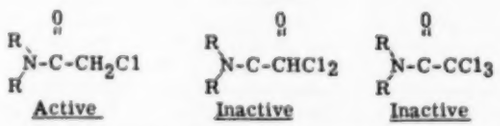
The a-Chlorine atom is one of the entities which determines the difference between activity and no activity:

Fig. 2



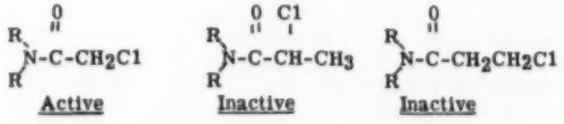
Activity appears limited to a monohalogen substitution. The di- and tri-chlorine substitution products are inactive or almost so:

Fig. 3



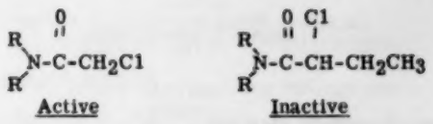
The a and b substituted propionamides are inactive:

Fig. 4



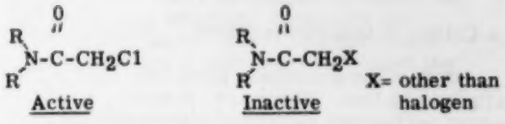
The a-Chloro substituted butyramides are inactive:

Fig. 5



To determine if the chlorine atom behaved as a simple toxiphore, other potentially toxic entities were substituted:

Fig. 6



Comparisons of chlorine, bromine, and iodine substitutions have been made. The a-bromo and iodo derivatives always have shown less activity than the a-chloro compounds.

Comparison of mono-N-substitution within the a-Chloroacetamides:

Fig. 7

Name	Activity
a-Chloro-N-methylacetamide	Active at 15 lbs./A
a-Chloro-N-ethylacetamide	Active at 10 lbs./A
a-Chloro-N-propylacetamide	Highly active at 5 lbs./A
a-Chloro-N-butylacetamide	Active at 10 lbs./A
a-Chloro-N-amylacetamide	Moderately active at 25 lbs./A
a-Chloro-N-tetradecylacetamide	Inactive at 25 lbs./A

Comparison of di-N-substitutions within the a-Chloroacetamides:

Fig. 8

Name	Activity at 5 lbs./A
a-Chloro-N, N-dimethylacetamide	Active
a-Chloro-N, N-diethylacetamide	Active
a-Chloro-N, N-di-n-propylacetamide	Highly active
a-Chloro-N, N-diallylacetamide	Highly active
a-Chloro-N, N-di-2-propynylacetamide	Highly active
a-Chloro-N, N-dibutylacetamide	Moderately active
a-Chloro-N, N-diamylacetamide	Inactive

While the all or no activity appears to be determined by the presence or absence of the a-halogen atom and the acetamide rather than the propionamide entity, the relative activity is modified considerably by the remainder of the molecule, i.e. the particular amine used in forming the compound.

The three carbon chain length appears to achieve some necessary requirement for maximum activity. This is evidenced by highly active propyl, allyl, and propynyl derivatives. It is also indicated by structural isomers of four and five carbon derivatives where the three carbon straight chain is present.

Comparison of the effect of structural isomerism as related to the optimum effect of the three carbon chain:

Fig. 9

Mono-N-substitution

Name	Activity Ratings
a-Chloro-N-propylacetamide	Active at 5 lbs./A
a-Chloro-N-isopropylacetamide	Active at 15 lbs./A
a-Chloro-N-butylacetamide	Active at 10 lbs./A
a-Chloro-N-isobutylacetamide	Active at 5 lbs./A
a-Chloro-N-sec-butylacetamide	Active at 5 lbs./A
a-Chloro-N-tert-butylacetamide	Inactive at 5 lbs./A
a-Chloro-N-amylacetamide	Moderately active at 25 lbs/A
a-Chloro-N-isoamylacetamide	Active at 5 lbs./A

Most of the compounds given have been obtained from aliphatic amines. There are, however, a number of very active derivatives containing heterocyclic substituents. A few of them are listed below:

Fig. 10

Name	Activity
4-(Chloroacetyl) morpholine	Highly active at 5 lbs./A
1-(Chloroacetyl) piperidine	Highly active at 5 lbs./A
a-Chloro-N-furfurylacetamide	Active at 5 lbs./A

Mixed aliphatic amines and mixed aliphatic aromatic amines have also produced highly active a-Chloroacetamide derivatives. The correlation study is based on pre-emergence action only and at specific rates per acre. Several of the derivatives labelled inactive in comparison figures are active at higher rates per acre or as contact sprays.

Summary

A new class of highly effective herbicidal chemicals has been described. These chemicals have proved outstanding for the control of annual grasses.

An extensive study of the various modifications possible has given us a picture of the correlation of structure and activity.

The interesting growth inhibition exhibited should be a fruitful field for continued study.

1/ Monsanto Chemical Co., St. Louis, Missouri

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HOW NOXIOUS WEED INFESTED MATERIAL VIOLATIONS CAN BE HANDLED

Dwight W. Lambert 1/

The subject that I have been asked to discuss is an interesting one. The answer to the question asked should be one that could be given in a few words, but as usual when a layman tries to esplain legal phrases it takes a little time and many words.

The violation of a noxious weed law as it applies to material infested with noxious weed seed is as serious as the violation of any of the laws or statutes of any state as pertains to misdemeanors. These laws were passed by Legislative bodies of our different states in most cases at the insistence of the citizens who wanted and needed protection from this type of action. In all cases that I know of, the noxious weed law was passed after much discussion, planning, and debate by people who are close to the field of weed control and perhaps the prospective law was even drafted just as they wanted it. In some cases the laws were not passed the first time they were introduced but needed to be changed or revised and reintroduced at the next session of the Legislature.

The point that I am trying to make is that our laws are not something that were written up and passed over night. Much work went into making them the best for the type of agriculture and administration found in the state concerned.

With the above in mind, one is able to comprehend much easier why a serious view should be taken in the enforcement of violations of our weed laws. Now the problem of how can violations be handled. One could easily say "in court" and let it go at that. This is the easy way in most cases for the official in charge of the program, and, of course, as far as the law is concerned it has been fulfilled, but let's examine this a little closer and see whether the damage done by the violations have really been repaired. In some cases the answer would be "yes", but in many others, I believe, to be truthful, we would have to say "no".

Take for instance the farmer who sells noxious weed infested wheat to the local elevators. The elevator in turn loads it on a car, and it eventually ends up in flour. A fine and publicity would be satisfactory and would probably teach a lesson to many while actually no appreciable damage had been done. However, say that the elevator sold the wheat to farmers for seeding purposes, which you all will agree is a poor practice, but is done rather regularly. And from the 500 bu. sold, to the elevator, 10 farmers had planted an average of 30 acres each on land which was free of any noxious weeds. In this case, would the small fine usually levied against the farmer selling the seed, be satisfactory settlement for what he had done and would it be enough if even the elevator was found guilty of the violation and also fined? What have we done to help and take away the damage done to the 300 acres of good land which was infested with a noxious weed?

This is, I think, where our laws need changing if a way is open to do it. I know that there is always the possibility of civil suit to recover damages, but isn't there a way in which this could be incorporated into the sentence when the individual guilty of such action is sentenced? This question is one I cannot answer, but is an answer each of us in the Regulatory field must find some way or another.

At the present time in Nebraska we try to get a conviction, depending on the circumstances, where a violation has occurred and then rather than turn a cold shoulder to the person who received damage from the transaction and violation of the weed law but didn't receive any compensation from the fine or penalty, try to help as much as possible in seeing that he receives a settlement. Although, this takes some maneuvering so as not to become too involved.

It is also possible sometimes to effect a just settlement out of court and have the person who had the damages receive more than otherwise might have been forthcoming. This, however, applies mainly where the infested seed or feed has not been planted or fed.

Of course, along with our strengthening of the laws so that equitable justice is done, we must have a program of inspection which will be strong enough to see that all violators are apprehended and punished. This is where many of us really fall behind. An alert inspection program would, I believe, keep our violations to a minimum and also provide an outlet for a good educational program which could be directed at the populace so that the actual damage which could occur would be known by all and respected.

The above is all right for intra-state violations, but what can we do about inter-state movement of infested material? At the present time - not too much, except set up cooperative agreements and programs to reduce to a minimum the amount coming in. We definitely need help in this type of work from the Federal Government with a law similar to the Federal Seed Act. This would allow a state with the cooperation of Uncle Sam's long arm to reach across the border into another state to obtain the violators of our law. This followed up with the process of justice mentioned before would adequately take care of the situation.

Our part in this work is not easy, as is usual, because it is done to and for the people we are continually associated with in the work of other sections of our weed laws. Therefore, I believe, that we must conscientiously always try to see that a fair and just settlement of a violation is always arrived at.

1/ Department of Agriculture & Inspection, Lincoln, Nebraska

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THE COUNCIL OF STATE GOVERNMENTS AND WEED CONTROL PROBLEMS

Marvin Fast 1/

The Council of State Governments is an agency established by law in each of the forty-eight states. As a joint governmental agency of the states, its financial support derives from appropriations by each state. It acts as a medium for improving legislative, administrative and judicial practices in the states; as an agency for furthering cooperation among the states in solving interstate problems, both regional and national; and as a means of facilitating and improving federal-state relations.

The Council is composed of Commissions on Interstate Cooperation in each state as official agencies of state governments. A typical Commission consists of ten members of the legislature and five administrative officials. The Commissions, working to improve state programs in many fields, are the bases on which the Council is founded. They also are, through the Board of Managers, the governing bodies of the Council.

The Council serves the states through such means as the

1) conduct of major research projects;
2) maintenance of inquiry and information services;
3) serving as a clearinghouse through which the states exchange information;
4) holding national and regional meetings in which state officials and legislators exchange information;
5) functioning as Secretariat for a number of national organizations of state officials. Included among these are the Governors' Conference, the National Association of Attorneys General, and others. Because of its activities for these Associations and its day-to-day work with individual state officials, legislators and legislative committees, the Council is in a position to bring to the service of each a wide understanding of the problem of all.

As a staff agency serving the Commissions on Interstate Cooperation, the Governors' Conference, and the other Associations which we serve as Secretariat, the Council of State Governments takes its direction, of course, from these bodies. The staff of the Council endeavors, in accordance with the directions of its governing bodies, to improve the processes of state and federal governments through such means as the planning of assemblies at which public officials and legislators consider mutual problems, through the coordination of ideas and recommendations, and through preparation of suggested legislation in a great variety of fields. As you will already have observed, we are in no sense experts on weed control problems.

My subject, however, is "The Council of State Governments and Weed Control Problems." We think we may be able to assist you in your efforts to solve numerous important problems in this field. And as important, we are certain that you can assist us in our service to state governments.

Specifically, there are three possible means in which we can perhaps be of assistance to you. Let me briefly and quickly outline these three methods.

First, the medium of the Council's Drafting Committee. Each year the Council brings together the Drafting Committee of State Officials, a body consisting of state legislators and officials with continuing membership. Its function is to prepare a program of suggested legislation in fields of current legislative interest in the states. The Committee's proposals cover many fields of governmental action and have in the past included suggested laws on important agricultural matters. The report of the Committee is widely distributed, going to the Governors, legislative committees, Attorneys General and others. As the title of the report implies, the Committee's proposals are simply suggestions to each state -- to be modified, accepted or rejected, and applied by each state in the light of its problems and governmental practices.

Suggestions to the Committee come from varied sources. Many emanate from one or more states which have developed helpful laws and ways of dealing with a given problem. Others come from federal agencies. A few originate with the staff. Before being referred to the Drafting Committee for its recommendation, all are widely distributed by us for comment and criticism. Proposals coming from the states pertaining to weed control laws, for example, would be submitted to the

Department of Agriculture and perhaps other federal agencies before being put on the Drafting Committee's agenda. Comments from administrators of state weed control programs also would be sought. Similarly with respect to suggested laws coming from federal agencies -- these are sent to state officials for comment and criticism. Their comments and suggestions are transmitted to the Drafting Committee.

A specific example in a field closely related to yours may be helpful. Some years ago the report of the Committee included the text -- along with an explanatory statement -- of the Uniform State Seed Law developed, as I recall, by the national association of state agriculture officials. Within the last year we have participated in discussions considering possible amendments to the Uniform Law. We have agreed with the National Association of Seed Control Officials to ask our Drafting Committee to study the amendments with a view to recommending them to the states. Certainly we would be most pleased to cooperate in a similar fashion with any legislation prepared by your group which you feel might be helpful to the states in dealing with weed control problems. So much for the work of the Drafting Committee.

The regular and special conferences arranged by the Council are a second possible means of assistance which I should like to describe very briefly. Both on a regional and a national scale the Council brings together state legislators and officials to explore ways of meeting some of the many problems that confront them. This joint discussion of problems among representatives of different states and among legislators and administrative officials is, we believe, valuable and most helpful. Your meeting here is a demonstration that you too feel such meetings are constructive. The solution of problems facing government requires the cooperation of administrative officials and legislators. Meetings such as ours create a wider understanding of problems among legislators and officials of the executive branch. And, of course, they result in continuous improvement in state programs. Here too, let me emphasize the willingness of the Council to cooperate in this manner. If you feel the need for a somewhat different forum, perhaps a broader one, for some of the problems you are trying to solve here, we would be happy to suggest at the appropriate time that your problems be discussed and your suggestions considered by meetings such as I have just cited.

Closely related to both of the above -- the Drafting Committee and the conference function -- is a third phase of the work of the Council of State Governments. I refer here to our efforts to promote better federal-state relations. I mention it separately because of the problems, which Mr. Gilbert has called to my attention, of weed control programs on federal lands. Through our Washington office we are able to maintain close contact with developments in Washington of interest to the states. At the request of our governing bodies, the Council has from time to time given special attention to problems between the states and the federal government. Improved federal-state relations, it should be added, demand that each level of government understand the difficulties and problems faced by the other levels -- and this, I would suggest, is never more true than in the case of programs where the American people expect the service and contribution of both the federal and the state governments.

1/ Midwestern Representative, Council of State Governments, Chicago, Ill.

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CO-OPERATION BETWEEN RESEARCH, INDUSTRY, EXTENSION AND REGULATORY GROUPS, IN THE ATTACK ON WEED PROBLEMS IN CANADA

E. G. Anderson 1/

Co-operation between research, industry, extension and regulatory groups is essential to the success of any attack on weed problems. Fortunately, it is easy to obtain. Difficulties which arise usually occur between the regulators and those who are being regulated.

Research information comes from two sources, (a) publicly owned research institutions and (b) private industries associated with production.

(a) A large amount of the information on fundamental and applied research has been, and is being, produced by the Canada Department of Agriculture. Extra mural grants to provincial Departments of Agriculture and to Universities assist in surveys for noxious weeds. The Experimental Farms Service is conducting some form of weed research at some 35 of their Experimental Stations located in each province. This work includes studies on the evaluation of herbicides, tillage, and seed cleaning equipment, and the relative tolerance of crops to herbicides.

Laboratories of the Plant Products Division, Production Service, conduct longevity and dormancy studies. Self contained Science Service laboratories at Kentville, Ste. Anne de la Pocatiere, London and Lethbridge, have plant physiologists studying how herbicides work and botanists who survey weeds in the area. The Botany laboratory of the Division of Botany at Ottawa, nas a weed investigation section studying the ecology, cytology, taxonomy, dormancy and incidence of all important weeds. They also review all applications for registration of herbicides.

Provincial departments also sponsor considerable research of a similar nature through Research Councils, Universities and Agricultural Colleges.

(b) The contributions which private industries make to our knowledge of "pure" or fundamental research on herbicides may be summarized as follows:

1. Development of herbicidal materials and screening of promising ones.
2. Determination of chemical methods of analysis.
3. Supply toxicological data.
4. Indicate physiological action.

Private industries through their plot and field tests also:

1. Confirm or disprove laboratory findings re volatility, potency, selectivity etc.
2. Demonstrate value in crop production.
3. Develop rates and time of application, carrier and method.
4. Indicate effectiveness and duration in different regions and on other soils.

In addition to making important contributions to research, industry as a whole assists the weed worker in many ways. A few of these would be:

1. Manufacture efficient standard tillage machinery, sprayers and seed cleaners.
2. Ensure continuous supply of this equipment and of pesticides.

3. Develop new machines and chemicals to meet new needs or make improvements.

4. Arrange for experimental testing of "promising" herbicides.

5. Publicize their products by press, literature, exhibits, radio, field days etc.

Extension men are vital to the whole weed control program. Their knowledge of farmers' problems and attitudes is invaluable to those who draft recommendations and regulations. Their sympathetic support of the recommendations and regulations have increased the numbers of farmers who have done something about their weeds. Industry also helps create good will through its supplementary educational program. Research and extension workers help industry's representatives and vice versa.

In Canada, there are several Acts which have a bearing on the weed control picture. The registration and sale of all pesticides is handled under the Pest Control Products Act. It would be comparable to the Federal Insecticide, Fungicide and Rodenticide Act in the United States. In Canada, however, there are no provincial acts which have anything to do with the registration or inspection of pest control materials.

The sale, importation, testing and inspection of seed for seeding purposes is regulated by the Seeds Act. It controls the total number of weed seeds, prohibits certain ones and limits the number of noxious weed seeds. This Act is governed on a grade basis.

The Feeding Stuffs Act should also be mentioned in this discussion, as it specifies the amount of certain weed seeds allowed in prepared feeding stuffs.

These Acts, namely the Pest Control Products Act, the Seeds Act and the Feeding Stuffs Act, are administered by the Plant Products Division of the Canada Department of Agriculture.

In addition to those mentioned above, the Canada Grain Act plays a role in the control of weeds by limiting their number in the grades established for wheat, oats, barley and rye, when sold for feed or for human consumption.

No provincial employees have any responsibilities to any of the above mentioned Acts.

Each province is entitled to, and most provinces have, their provincial weed control acts. In most cases, the enforcement officers also do extension work in cooperation with extension or agricultural representative services.

The National Weed Committee in Canada is perhaps the best example of how research, industry, extension and regulatory groups can and do co-operate. It is composed of key representatives from Experimental Stations, Universities, Agricultural Colleges and Departments of Agriculture, who meet regularly with technical representatives of the trade. The status of all projects is considered and programs are drafted to cover all important weeds or weed problems. Recommendations for the control of weeds by herbicides or other methods are adopted. These are usually accepted by the administrators of the Pest Control Products Act and, in turn, by the trade.

Information from all these groups is reported freely at the meetings and frequently is incorporated in the legislation concerned. These meetings provide incentives and new ideas. Deadlines for the presentation of reports maintain a steady flow of valuable information.

As industry develops new chemicals, these groups provide the means by which a systematic testing can be carried out with the greatest efficiency.

Another example of how research, industry, extension and regulatory groups co-operate is in the operation of provincial advisory or weed control committees. All groups work together for the common good in the operation of weed control projects, or in production of literature such as herbicidal recommendations etc.

Co-operation between these groups is possible, and practical, and can bring about a steady flow of fundamental and applied research data, a stronger and more effective extension group and acceptably improved legislation.

1/ Sec'y., National Weed Committee, Dept. of Agric., Ottawa, Ontario

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ESSENTIALS OF A COUNTY WEED CONTROL PROGRAM

Cecil Sanderson 1/

Weed fighters, I think that I can best convey to you the essentials of a weed control program by telling you how such a program is set up and operates in counties of South Dakota.

Before doing so, however, I would like first to comment regarding the broad and basic principles upon which our county weed program is founded. These principles are ORGANIZATION, EDUCATION, and the ENROLLMENT OF ALL COUNTY FARMERS in a county's weed control program.

ORGANIZATION, as in government, military, politics, or any undertaking involving a large number of people is the foundation upon which ultimate success must rest. Little lasting progress is accomplished without the firm foundation of a planned, working organization. Organization multiplies the efforts of a few. It is the highway over which an effective weed program must pass. It comes first, it is basic, and is the means whereby the steps of a successful county weed program must logically be effected. Organization is probably that basic essential too often by-passed, or only half heartedly accomplished. It is by-passed because it takes time, planning, effort, and because the key position it occupies in furtherance of a successful weed program is generally not well understood. Organization is oft times not carried out to the desired degree because we are not sufficiently aware of those underlying traits of human nature that motivate people to unified action.

A dynamic, well timed EDUCATIONAL program must be launched simultaneously with the organizational phase of a county weed control program. An argument as to which comes first, organization or education, might well resolve itself into the age old adage, "which comes first - the chicken or the egg". These two basic principles must

occur together as organization itself is the result of, and a part of, the educational phase of a weed killing county program. They are inseparable. One can not be effectively accomplished in the absence of the other. Many communities, counties, yes, even states, have ineffective or defunct weed eradication programs because they neglected, or did not appreciate, the necessity of basing their program on the solid foundation of organization and education. In their haste to reach their objective, they chose the "easy" shortcut method of direct enforcement. We, in South Dakota, need only to recall our T. B. eradication program of some years back to appreciate the resistance that can and will develop where a program involving many people is launched and pushed through apart and unpreceded by a thorough educational program. We humans basically resist that which we do not understand. Education is understanding.

The third basic principle, 100 percent ENROLLMENT OF THE FARMERS in a county's weed control program, gives the farmers concerned the feeling of belonging - the feeling of importance to the program - endows upon him a sense of responsibility and tends to dispell the defeatist attitude that unattended, encroaching noxious weeds has upon him if his neighbors are not in the program with him.

Keep these three fundamental principles, organization, education, and 100 percent enrollment, in the back of your mind and observe how our county weed program is built around them.

Now, what is the county weed control program in South Dakota? How is it set up and how does it function? Our South Dakota Weed Law basically is an enabling act, an act that establishes a State Weed Board. This Board is impowered by our weed law to adopt certain regulations deemed necessary to the formulation of an effective weed control program throughout South Dakota. The regulation, therefore, under which our county weed control programs are set up and function are those formulated by the South Dakota State Weed Board.

The initiation of a county weed control program is the responsibility of the county agricultural Extension Agent. The first step of the County Agent, in initiating a county weed control program is that of holding educational meetings in all ASC communities in the county. It is presumed, of course, that a noxious weed problem does exist, that the farm people of the county do, in general, recognize this growing menace and are desirous of doing something about it. And further, that various farm organizations, such as a county Crop Improvement Association, support or even co-sponsor the initiation of a county weed control program.

I quote from our regulations regarding these community educational meetings - "After the weed program has been explained at the community meeting place, the farmers present nominate and elect by ballot a member who will represent said community in the election of the members of the county weed board."

What goes on at a community educational and election meeting? Here, briefly, is a typical agenda for a community meeting in Roberts County: an entertainment film starting promptly at the time specified; a recent weed control film; a colored slide talk dealing with the latest weed control methods; an explanation of the organization of the county's weed control program, ASC payments available, etc.; election of a community weed representative for the coming year and, finally, free coffee and doughnuts. The county weed supervisor and the county agent conduct these meetings cooperatively with the county agent carrying the bulk of the educational part of the meeting and the county weed supervisor concentrating on the organizational aspects of the county's weed program. These annual community educational and election meetings are usually held during February, but not later than March 15.

The community weed representatives thusly elected, (we have twelve in Roberts County) meet shortly after the last of the series of community meetings to elect from among their number, a three membered County Weed Board. One member of this board will be elected to serve a three year term, one a two year term, and the third is elected each year to replace that member whose term expires. The County Weed Board should and must be weed-fighting farmers - public spirited farmers in whom their neighbors have confidence and who delight in killing weeds. They are a public body vested with the power of supervising the county's weed control program. Such a program will be no better, nor more successful, than they make it. They should merit the support of every farmer in the county they have been elected to represent.

We now have our Community Weed Representatives, and our County Weed Board elected, but as yet no mention has been made of the working or weed killing segment of our county weed control program. The army has its basic, fighting unit - the squad. So too does our weed program embody a group designed such as to work at close quarters with our common enemy - weeds. This segment of our county weed control program is the Neighborhood Weed Control Unit, with its democratically elected leader. How are these units established? The County Weed Board, with the counsel and advice of the Community Weed Representatives, county and township supervisors and others divide the various communities into closely knit neighborhoods of ten to thirty farmers. Many factors are taken into consideration in setting up Neighborhood Weed Control Units such as simularity in crops, soils, size of farm and troublesome weeds. Physical barriers such as streams, hills, lakes and dry-runs oft times serve as natural boundaries of neighborhood units. The farmers living in each of the Neighborhood Weed Control Units are called together by the community representative. An agenda for this meeting might be: an explanation of our county's weed control program; our neighborhood weed problem and how to deal with it; the purpose and function of the Neighborhood Weed Control Unit and election by ballot of the neighborhood leader for the coming year. The neighborhood weed control unit leader, like a squad leader, works closely with his community representative (platoon leader). We have 117 such leaders in Roberts County. Here in the Neighborhood Weed Control Unit, is where the organizational work of our whole County Weed Control Program pays off. Here is where a farmer, desirous of keeping in the good graces of his neighbors, takes a new look at his blooming thistles and does something about them. Here's where the business of killing weeds begins and weeds exit. The ultimate goal of any County Weed Program is to have the county blanketed with Neighborhood Weed Control Units of ten to thirty farmers, all working together to exterminate their common weed menaces.

Besides the actual organization as set up for weed control as just explained, our South Dakota Weed Law embodies other features which contribute directly or indirectly to this business of killing weeds. Not the least of these features is the authorization of the Boards of County Commissioners and other governing bodies to appropriate and expend money to pay county weed board expense, buy and sell weed chemicals to farmers at cost, and to hire a county weed supervisor. It costs money to fight weeds but, as Charles Gilbert, our state weed super-

visor so aptly puts it, "it costs more to keep weeds than to control them". An adequate County Weed Budget, therefore, is essential to a successful weed control program. Here's where our County Commissioners come into the county weed picture. They should and must be, in on the county's weed control program from the start. Being told that the investment of county tax money for weed control purposes is a good investment is not enough - they must KNOW. They are entitled to know and must be confident that they are spending tax money wisely if they are conscienciously performing their job as a member of a Board of County Commissioners. And they are not likely to know unless they have attended the educational meetings or otherwise been given the weed facts. If they grow up with a well planned and executed weed program, they will support it.

I mentioned a bit ago that county tax money could be used to hire a county weed supervisor. Once the weed program is initiated and regulations followed in the election of the County Weed Board, Community Weed Representatives, and Neighborhood Leaders, the biggest simple factor contributing to its long range effectiveness and success might well be an energetic, well-informed, full time County Weed Supervisor. He is the working arm of the County Weed Board. Weed fighting chores sprout up like weeds themselves when farmers in a county become weed conscious and have the assurance that something can be, and is being, done. The county agent already has a full time job. He should not abandon his 4-H clubs, livestock programs, etc. to attend to the multitude of weed killing jobs that normally follow in the wake of a launched County Weed Control Program. These jobs can well occupy the full time of a county specialist, the County Weed Supervisor. Although his activities are closely correlated to those of the county agent's, his work is supervised by the County Weed Board. Cooperation and planning between the county weed supervisor and county agent is a must.

What are the advantages of a well organized, smooth running County Weed Control Program?

First, you are set up for a long time program. Not just for one or two years, but for twenty years or more - if necessary. Such a program easily gains momentum if the gravity of weed problems dictates. You are set up to deal effectively with new weed menaces if and when they occur. You can maintain the upper hand on weeds, and fight them to the finish. You're in the weed killing business to stay.

An organized County Weed Program encourages voluntary cooperation. Enforcement, although sometimes necessary and provided for in our State Weed Law, is oft times resented and not looked upon with favor in our democratic society. Organization and education reduces the necessity of enforcement to a minimum.

An organized County Weed Program carries with it public recognition, support and respect.

An organized weed program is a democratic setup from start to finish. Every leader in the program, as provided for in the regulations of our State Weed Board, is elected by those farmers they represent.

Our County Weed Program, as set up, allows for maximum flexibility. This is very important as different noxious weeds in different neighborhoods require varying methods of control.

An organized program fosters community pride. It is comforting and a challenge to every farmer to know that his neighbors are in the program just as he is. He can not knowingly, through neglect of his weeds, infest his neighbor's farm and, at the same time, maintain his neighbor's good will and respect.

Since an organized County Weed Program is a stable organization, operating under state laws and supervised by a recognized county public body, county financial support usually is not, and should not, be a major obstacle. The Board of County Commissioners know that the money they appropriate for county weed control will have adequate supervision and will be spent for the mutual benefit of those who pay the taxes. They know that their decision to appropriate funds for weed control has the support of those they represent.

Organized weed control is soil conservation in its most elementary concept. All of us have knowledge of land, yes even farms, overrun by noxious weeds that is all but worthless from the standpoint of profitable crop production.

An organized County Weed Program enhances the value of the land it encompasses. Wouldn't you pay more for a farm or consider the farm which you may now have of greater value if you had assurance that you, and your sons to follow, would not have to wage a perennial battle on encroaching weeds?

An organized weed program is a weed prevention program. Although, at the time of its inception, the weed program may have been organized to eliminate and curtail existing weed menaces, it also serves to prevent the establishment of new patches of the same weeds or of introduced weeds. A County Weed Program is crop insurance in its most elementary concept.

Organization lends efficiency, reduces duplication and eliminates unwarranted confusion and frustration. A noxious weed patch once discovered need not be the source of a neighborhood row. If not promptly dealt with by the farmer immediately concerned, a chain of command is provided for in the weed law that gets the job done - and is accomplished normally within the boundaries of the Neighborhood Weed Control Unit.

A county organized for weed control may secure state enforcement if necessary. Although enforcement is seldom required it is there and serves to assure cooperating farmers that they need not tolerate indefinitely re-occuring weed infestation from an adjoining farm.

Our County Weed Program is designed for, and serves admirably as, an educational media. New weed chemicals and new methods of weed control seem to sprout up over night. These findings of research such as is revealed at this conference must be passed on to the farmers for whom it was intended and who can use it. This is the responsibility of the Extension Service. The organizational framework of the County Weed Program is the county agent's main educational pipe line to the farmers of his county.

An organized weed program multiplies the efforts of the county agent, the county weed supervisor and the various elected program leaders. It provides a system of getting the weed killing job done. It divides the load of leadership and delegates responsibilities.

An effective weed control program causes farmers to become weed conscious and therefore alert to recognize infestations in their infancy. Noxious weed infested farms become so because someone did not know what the offending weed looked like. Noxious weeds are stopped before they get started.

An organized County Weed Program makes possible the purchase of weed control chemicals, particularly soil sterilizers, in car load lots and the reselling of them to farmers at near cost price. Not too many car loads of sodium chlorate and boron chemicals are needed to save county farmers the sum appropriated for County Weed Control. For reasons of limited storage space and insurance restrictions, business concerns do not object to the county accepting this responsibility.

And finally, an organized County Weed Program developes leadership. Farmers who have never been in a position of leadership lose their timidness before groups in their zeal to kill weeds. The delegation of responsibilities inherent in our weed organization serves to spark the latent talents of leadership - leadership talent that they themselves did not realize they possessed. This acquisition of leadership ability carries over into many other fields and programs.

By way of summary, please let me remind you - education, organization, and the inclusion of all farmers of the county in the county's weed control program is basic and a must if a long range successful weed control program is to be realized. Time, planning, and cooperation are close allies of success. There is no shortcut. Weeds are persistent. They grow while we sleep. We in South Dakota, are confident that a well organized County Weed Control Program is a major contribution to the successful control and eradication of noxious weeds.

1/ Roberts County Agent, Sisseton, South Dakota

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RESULTS OF THE LAMOURE COUNTY, NORTH DAKOTA, DRILL BOX SURVEY

Henry N. Ness1/

The drill box survey was sponsored by the County Crop Improvement Association and the County Agent's Office. It was felt that the majority of seed being used was not good seed, therefore, the purpose of the survey was to find out exactly the quality of seed used.

The County Agent's Office made the survey with the cooperation of the LaMoure County farmers during April and May of 1954.

The method used in securing samples was that whenever I was driving around in the county and a drill was operating, I would stop and, with permission of the farmer, I took a representative sample of seed out of his drill box. From this sample the following information was obtained.

Where Seed Was Cleaned:

No. Samples	Home Cleaned	Custom Cleaned	Not Cleaned
62	20	42	0

Germination Test:

No. Samples	Had Tests Made	No Test Made
62	25	37

Seed Treatment:

No. Samples	Used Ceresan	Used Panogen	No Treatment
65	31	2	32

Weed Content of Seed: From each sample of seed a pound was analyzed for number and species of weed seed by the office secretary, Rita Thomas. The Following list is the average weed content found in one pound of seed:

Average Weed Content of One Pound of Seed	
41 Yellow Foxtail (Pigeon grass)	7 Wild Oats
40 Green foxtail	3 Quackgrass
27 Wild buckwheat	1 Pigweed
10 Lambsquarters	41 Other crop seeds
9 Common Mustard	179 Total

As soon as each sample was analyzed the information was sent direct to the farmer from whom the sample was taken. A seed of each weed found in the seed grain was also attached to the letter.

Rate of Seeding of Weeds: In addition to the above information, we calculated the number of weed seeds seeded per acre and this information was also sent to the farmer as follows:

Weed Seeds Seeded Per Acre	
2,952 Yellow foxtail	504 Wild Oats
2,880 Green foxtail	216 Quackgrass
1,944 Wild buckwheat	72 Pigweed
720 Lambsquarters	2,952 Other Crop Seeds
648 Common Mustard	12,888 Total

To point out the seriousness of seeding weed seeds, the following information was presented to the farmers:

Seed Production of Weeds

Prohibited Noxious Weeds:
1. Leafy Spurge (1 stem). 140
2. Canada Thistle (1 stem). . . . 680
3. Creeping Jenny. 110
4. Per. Sow Thistle (1 stem)... 9,750
5. Peppergrass. 6,000

Restricted Noxious Weeds:
1. Common Mustard. 2,700
2. Wild Morning Glory. 95
3. Wild Oats. 250
4. Dodder 16,000
5. Frenchweed 7,040

Common Weeds:
1. Wild Buckwheat 11,900
2. Green Pigeon Grass 34,000
3. Yellow Foxtail (Pigeon Grass) . . . 6,420
4. Lambsquarters 72,470
5. Pigweed 117,400

Originally all weeds apparently get a start in an area by being in seed grain. Fields which may become almost solid with Leafy Spurge were originally infested through flax seed.

We believe that the survey taken in LaMoure County made many people conscious of poor seed and that many farmers will demand better seed in the future.

1/ Cass County Agent, Fargo, North Dakota

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THE MINNESOTA WEED LAWS

Sig. Bjerken 1/

Under the Minnesota Weed Law any annual, biennial or perennial plant that is injurious to public health, public roads, crops, livestock and any other property is considered a noxious weed and may be destroyed at such time and in such manner as is determined by the commissioner or local weed inspector having jurisdiction. In other words, as new noxious weeds appear in our state we do not need new legislation to deal with them. This is an important feature of our law.

The State of Minnesota is subdivided into 1841 townships and 802 villages and cities, of which the three town board members of the townships and the mayors of the villages and cities are weed inspectors by law.

The law further provides they shall check every tract of land under their jurisdiction and cause to be destroyed weeds which exist thereon. Good supervision is important in any program.

The township boards and village mayors may appoint assistants.

The law requires a legal weed notice published before June 15 each year by each township and village to the effect that weeds shall be destroyed by June 15 and as often as necessary thereafter to prevent them from going to seed.

The law further provides that upon failure to comply with the general weed notice the local weed inspector may enter upon any property and cause to be destroyed weeds existing thereon without further notice, provided the expenses incurred are paid by the township or village as the case may be. If the expenses are to be charged against the property, in that event a personal service of the notice must be given and upon failure to comply with the notice within the time given and in the manner provided, the local weed inspector is, under the law, given the power to carry out the requirements of the notice and the costs incurred are added to the taxes.

The law also provides that the County Boards, upon the request of the Commissioner of Agriculture, shall appoint a county weed supervisor to supervise the program of the county. All of the 87 county boards of the state have complied with this provision. It is our opinion that no county weed program can be successful without a county weed supervisor.

Minnesota has an area of approximately 51,000,000 acres, of which 15,000,000 acres are known as tax exempt lands. However, under the law we may enter upon any land to destroy weeds if those in charge fail to do so, since the legislature of our state realized that all lands may become infested with weeds. Therefore, they provide funds necessary for weed control on tax exempt lands.

On lands on which owners are financially unable to pay the costs of weed eradication the law provides the commissioner may quarantine such tracts and the costs incurred are paid on a basis of 10% by the township, 20% by the county and 70% by the state when the quarantine is located in a township. When the quarantine is located in a village the costs are paid 50% by the village and 50% by the state. Many infestations in our state would have gotten out of hand had it not been for this provision.

There are many other features of the Minnesota Weed Laws which could be mentioned, but time does not permit me to do so. Therefore, may I summarize the law as follows:

Weeds on all lands, whether they are located on property where the owner is financially able to pay the costs or on land where the owner, operator or agent is unable to pay the costs, or on tax exempt lands, railroads, cemeteries, state, county or township roads, can be destroyed by the local weed inspector upon the failure of those in charge to do so.

Under the law any weed that is harmful to crops, livestock, health or other property may be destroyed, and may I say, even though this provision has been on the statutes of our state for many years, no criticism has been forthcoming as to this provision.

Under the law there are three inspectors in each of the 1841 townships, or 5523 inspectors, and at least one in each of the 802 cities and villages in our state.

The law is administered by the Commissioner of Agriculture, through the Director of the Division of Plant Industry, under the Supervisor of the Section of Weed Control, aided by an agronomist and eleven weed and seed inspectors each having a district, who not only supervise the weed program in their districts, but also are the seed, feed and fertilizer inspectors of the state.

With such supervision we are in a position to render service almost immediately in any section of the state.

Finally, may I say, the Minnesota Weed Law is fair since it gives the individual the first opportunity to take care of his own weeds.

1/ State Weed Supervisor, Bureau of Plant Industry, University Farm, St. Paul 1, Minnesota

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THE FARMER AND HIS SEED

J. D. Furrer[1/]

Statements are often made about the kind of seed that farmers plant. There's a wealth of information available on the subject. When the 17 states and provinces in the NCWCC were contacted, eight of them supplied information, (Table I.).

Table I. Source of Data

State	Years Data	No. Surveys	No. Samples	Crops
North Dakota	1	1	385	Wheat
South Dakota	1	1	324	Barley, Oats Wheat, Flax
Minnesota	1	1	45	Barley, Oats Flax
Michigan	1	1	372	Oats
Iowa	1	1	116	Oats
Nebraska	4	11	1225	Oats, Wheat
Saskatchewan	1	3	2407	Oats, Barley Wheat
Alberta	6	18	6530	Oats, Barley Wheat

Seed source: Where do farmers get the small grain seed that they plant? These surveys show that over two-thirds of them plant their own seed and about 20% obtain it from their neighbors. These two sources account for approximately 85% of the small grain planted.

Table II. Seed Source (Percentages)

State	Own Seed	Neighbor	Seedsman	Other
North Dakota	68.0	20.0	12.0	0.0
Iowa	67.0	19.0	14.0	0.0
Nebraska	69.0	24.3	4.4	2.3
Saskatchewan	78.6	17.2	1.3	2.9

Seed Cleaning and Treating: Iowa experimental work shows that cleaning and treating means an increase in oat yields of 3 bushels per acre. The data below shows that in northern areas more farmers clean and treat their seed.

Table III. Seed Cleaning and Treating (Percentages)

State	Recleaned	Treated	Tested For Germination
North Dakota	98.0	70.0	57%
South Dakota	48.1		
Iowa	70.0	34.0	58%
Nebraska	53.2	32.1	41%
Saskatchewan	93.5	56.5	
Alberta	98.7	86.9	

Some of the high figures in the "recleaned" column are perhaps best explained by a statement extracted from the Alberta report: "Only 1.3% of the samples were reported uncleaned, but reluctance on the part of the farmers to report grain in the seeder box as uncleaned, is understandable." Many samples reported as recleaned could cause one to wonder what they were like before they were cleaned or what kind of equipment was used to do the cleaning. In North Dakota 270 samples cleaned by local elevators averaged 175 weed seeds per pound with one sample containing 1,264 seeds per pound; 81 samples cleaned at home averaged 200 weed seeds per pound with one sample containing 1,560 weed seeds per pound, but 13 of the home cleaned samples were free of weeds; 7 samples that had not been cleaned at all averaged 1,100 seeds per pound; 26 samples cleaned by approved cleaning plants averaged 44 seeds per pound.

The Alberta survey showed the following results with various cleaning methods:

Table IV. Alberta Cleaning Methods and Results

Method	% No 1 Seed	% No 2 Seed	% No 3 Seed	% Rejected
Elevator	24	7	24	45
Farm	29	12	18	41
Other Plants	33	9	15	43
Portables*	60	20	5	15
Municipal Plants	70	17	7	6

*Cleaned only wheat

Germination: 57% of the North Dakota farmers were testing the germination of their seed; one sample germinated only 15%. In Iowa 58% of the collected samples had had germination tests. In Michigan 6.7% of the samples germinated below 70%. Forty-one per cent of the Nebraska farmers were testing for germination.

Weed Seed Content: Nebraska collects the dubious honor of finding a small grain sample containing the most weeds--11,700 weed seeds per lb. of grain. In North Dakota one farmer was seeding 486,720 weed seeds per acre while in South Dakota one individual was planting 11 weed seeds per sq. ft. or 479,160 per acre.

Table V. Weed Seed Content

State	No. of Weed Seeds No./lb. Grain	Range	% of Samples Containing Primary Nox.	Sec. Nox.	% Weed Free
North Dakota	190	0-6,084	3.0	82.0	3.4
South Dakota	249 (?)		12.9	69.1	
Minnesota	91*	0-794*	0.0	55.6	0.0
Michigan	24.7%	0-2054	29.6	4.6	
Iowa	over 100	0-999	0.0	27.6	44.9
Nebraska	150	0-11,700	1.5	28.7	30.8

*Objectionable weeds

Quackgrass was the most found noxious weed in Michigan while wild buckwheat, foxtail, barnyard grass, smartweed, lambsquarters, and dock were the most often found common weeds. In Iowa mustard and dock were the most numerous secondary noxious weeds; one seed sample contained 342 dock and 144 mustard seeds per lb; wild buckwheat, smartweed, foxtail, wild vetch and lambsquarters were the most numerous common weeds. Secondary noxious weeds of Minnesota which showed up most were wild mustard and quackgrass while wild oats and vetch were the most found common weeds. In Nebraska field bindweed was the most prevalent noxious weed; wild mustard, pennycress, and dock the most found secondary; the common weeds most frequently found were wild buckwheat, foxtail, wild brome, smartweed, and lambsquarters. In North Dakota 27% of the samples collected contained more than 100 wild oats per pound while 45% of the samples contained over 100 weed seeds per pound; The most common annual weeds were wild oats, mustard, wild buckwheat, foxtail, and sunflowers. Some South Dakota samples indicated that 70 noxious weed seeds per square rod were being seeded; field bindweed and quackgrass were the most found noxious weeds; wild oats was found in 54% of the samples; the most common annual weeds were wild buckwheat, wild oats, foxtail, mustard, and sunflower. In Saskatchewan wild oats and wild buckwheat were the weeds most prevalent in the samples; wild mustard, stinkweed, and lambsquarters were also fairly abundant. Seeds of 90 species of weeds and 17 other crops were identified. In Alberta wild oats are seeded by more farmers in larger numbers than any other serious weed. One sample collected contained 820 per pound. Tartary buckwheat caused the second highest rejection of samples.

The following table on a 1913 Alberta Seed survey is of interest. At that time about 40% of the farmers were seeding noxious weeds. But the figures also show that over 30% were using weed free seed, (Table V1).

Table V1. 1913 Alberta Seed Survey - 263 Samples

	Wheat	Oats	Barley	Flax	Total
No. of Samples	66	132	59	6	263
Noxious Weed Seeds					
No. Samples Free	50	75	32	3	160
Largest No./lb.	689	1216	2539	32	
Other Weed Seeds					
No. Samples Free	14	42	24	3	83
Largest No./Lb.	1379	2405	2752	656	
Other Crop Seeds					
No. Samples Free	23	2	1	4	10

Better Seed Grades: Table V11 shows the results of a survey on certified seed.

Table V11. Condition of Certified Seed

	% Planting Certified Seed	Weed Seeds Per Lb. Certified	Weed Seeds Per Lb. Non-Certified
Ave. (eleven counties)	5.1	1.2	159.6
Adams (wheat - 1951)	0.8	2.0	574.0
York (wheat-1951)	2.5	3.5	246.0
Dixon (oats-1952)	0	--	247.0
Cheyenne (wheat-1952)	14.2	0.3	5.7
Hitchcock (wheat-1952)	3.1	0	16.8
Fillmore (oats-1953)	5.4	0	254.0
Richardson (oats-1953)	3.2	2.0	29.6
Lancaster (oats-1951)	5.4	2.0	83.5
Banner-Kimball (wheat 1953)	4.0	0.0	11.6
Madison (oats-1954)	8.9	2.0	175.4
Cedar (oats-1954)	8.6	0.5	112.3
Iowa	7.0		
North Dakota	5.0		

In Iowa where 7% of the farmers were planting certified seed, the previous years production of certified seed was only enough to supply 4 or 5% of the total acreage. 2.1% of the oats and barley and 3.5% of the wheat planted in Saskatchewan were certified or registered.

Summary

Over 85% of the farmers plant their own seed or obtain it from their neighbors. To improve the quality of seed going into the ground the primary efforts should be directed to the individual farmer.

About 80% of the seed being planted goes through a recleaning operation. Much recleaning is of questionable benefit. Cleaning done by farm plants and by local elevators has been least efficient. Approved processors and plants operating for the specific purpose of cleaning seed are doing the most acceptable jobs.

Approximately 7% of the seed samples contained primary noxious weeds and about 40% contained secondary noxious weed seed.

Certified, registered, and foundation seed grades were free of primary noxious weeds and contained only a small fraction of the common weed seed found in other grades.

1/ Agronomy Dept., University of Nebraska, Lincoln, Nebraska

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WEED LAWS ARE IMPORTANT

Vernon W. Woestemeyer 1/

Weed laws are important for the protection of farmers and farm land. Most weeds can be controlled with good farming practices. They will not be eliminated, but usually can be controlled to the extent that they need not render a crop a total loss, or nearly so. However, some weeds defy a crop to compete with them.

With the persistence and spreading habits which some of these weeds have, once they are established they are extremely difficult to eradicate.

In addition to these characteristics, many of the weeds we associate with this group are prolific seed producers, and some of the seed is capable of retaining its viability while lying dormant in the soil for years. On the experiment station at Hays, Kansas, bindweed seedlings have appeared in a field which at one time was infested with bindweed, but in which no seed had been produced in 30 years.

This is the problem we face: Deep-rooted perennial weeds that spread by lateral roots or rhizomes, that are prolific producers of seed, some of which can lie in the soil for over 30 years and then germinate to start a reinfestation. Some of these weeds are, in addition, very able competitors with other plants and prevent or drastically reduce crop production. In several states it was considered essential that something be done to control some of these weeds that had become a state-wide menace. Research projects were started, and extension meetings were held to give farmers all the information available on how to control these weeds. Research and extension workers have done a tremendous job of devising methods of control and passing the information along, and they still are doing so. They were instrumental in Kansas in getting the original bindweed law passed, because it was felt that more should be done. Farmers needed more help in controlling bindweed. Under the bindweed law county weed departments were set up under state supervision. The County weed supervisors organized cultivation rings among farmers and put tractors and duckfoot cultivators to work and furnished chemicals at half cost for bindweed control.

Fortunately, enforcement procedures were included in the law. They have seldom been used, but without them the work would be seriously handicapped. Uncooperative farmers could make it impossible for neighboring farmers to obtain any permanent results because they would be supplied with a new crop of seed every year.

Another problem that can't be overlooked in a noxious weed control program is concerned with the prevention of spread of the weeds through infested material. It is futile to try to eradicate and prevent the spread of weeds without controlling the distribution of seed of those weeds and material infested with them. This hazard has been reckoned with in connection with seed through state pure seed laws. It is just as important to control the disposition of other material containing noxious weed seeds. A noxious weed law or some other similiar law seems to be the best way to close the gap.

There was no provision for this prevention of spread in the original Kansas bindweed law, but its need soon became apparent. The law was amended to make provisions governing the disposition of this infested material. It has become one of the most important parts of our law. The inspection of carloads of feed grain consigned to Kansas in 1953 is an illustration. Of the 4315 cars inspected, 2002 were rejected because of the presence of field bindweed. It's difficult to estimate the damage that would have been done if all that bindweed-seed-infested feed had come into Kansas, been fed to livestock, and then scattered on our fields, still viable, as most of it would be.

As in the case of control programs on the farm, we have very little difficulty with our inspection work. Most of the people whose material is rejected recognize the necessity of controlling the spread of these weeds and welcome our inspection program. The same is true of the attitude of custom harvester operators when we check their equipment. Nevertheless, one point is evident. While most people recognize the need to control noxious weeds and prevent their spread, the job would not be done as effectively as it now is in our area without a weed law which makes possible the leadership, services and protection on which the people rely.

1/ Kansas State Board of Agriculture, Topeka, Kansas

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WEED LAWS ARE IMPORTANT

Crawford Winton 1/

Weed Laws are important and certainly have a place in our overall agricultural programs. When millions of dollars are spent and lost annually by the people we serve on weed infestations, land devaluation, and crop yield reductions, it presents to us as Control People a challenge which we should not pass off lightly.

Many times, I am sure, we feel that our laws are inadequate and facilities limited, causing us to become somewhat discouraged by the actual enforcement that we may obtain under our present weed control laws. However, I definitely agree that any type of weed law is better than no law at all. I make this remark for the benefit of those who may be contemplating legislation towards the passage of Weed Laws and Weed Infested Material Acts, or for those who may already have laws, but feel they are inadequate. The State of Oklahoma falls within the scope of the last category.

May I briefly explain what has happened in our state so far as our Weed Law is concerned. Oklahoma was the first state to attempt to pass through the Legislature the "Uniform Weed Infested Materials Act" as proposed and adopted by this Association. The possibility of its passage looked good, until the definition of Noxious Weeds was studied by the committee. Originally this definition stated that "the term Noxious Weeds shall mean bindweed and such other weeds declared to be noxious by the State Board of Agriculture after public hearing." This definition met opposition and after final approval, bindweed was all that was considered as noxious under the act. However, we are trying again in January, 1955 to add the original phrasing of the definition. Even though we were somewhat discouraged

at the time, still, something basic had been established on which we could build. Also, there were no funds granted to carry out the operational expense of such a program. In view of this, it became necessary that the Weed Infested Materials Act be placed under the jurisdiction and direction of the Seed, Feed and Fertilizer Division of the Oklahoma State Department of Agriculture, and because of existing circumstances is confined to bindweed in whole grains.

We have not become discouraged, as a matter of fact, this law has helped us tremendously in our allied Seed and Feed Laws, without same, our control over these two commodities containing noxious weeds would have been limited. Another advantage under our present conditions is that the same inspectors may be used for all three of these materials. We have found this beneficial, not only from a psychological point of view, but for more stringent action that can be applied to "on the spot" enforcement.

Possibly some examples of how these laws work together in our State would better clarify the point I have just made. For example: in the Oklahoma Feed Law, whole grains are exempted and are not classified as a commercial feed. However, when whole grains are found by our inspectors to contain bindweed, the "Weed Infested Materials Act" is applied and same suspended from sale until the grain has either been destroyed or ground fine enough to destroy the viability of the weed seed. This action has been taken on a number of shipments of oats which were being sold under the "Drought Emergency Relief Program." Another example in which the Weed Law and Feed Law works effectually together, is in the shipments of screenings made into our state. Our Feed Law states in part, "Any commercial feed sold in the state of Oklahoma must first be registered with the State Department of Agriculture." Further, "Any commercial feed listing any type of screenings as an ingredient, a sample of those screenings must first be submitted to the Department for approval before acceptance of the registration." Also, "The distribution of commercial feed in Oklahoma is prohibited if same contains whole or injurious weed seeds." When these materials that are infested are received in our office, many times both the Feed Law and Weed Law may be applied and the sample rejected.

The same analogy could be applied to our Seed Law. As many of you know, Seed Laws usually have their noxious weeds defined and separated into two groups, namely prohibited and restricted. Under existing applications of these two groups and the wording of these laws, recognized tolerances are applied to the number found by actual laboratory analysis. These tolerances have been arrived at mathematically and are recommended by the "Association of Official Seed Analysts". With this brief background, the following example could be made. Let's assume that a lot of seed was shipped into our state and labeled in accordance with the provision of the Federal Seed Act as well as our state seed law. We find that this seed was labeled, noxious weeds "none"; whereas upon sampling and analyzing the seed we find noxious weeds (bindweed) at the rate of 2 per pound. Under our Seed Law, even though bindweed is prohibited, after applying the tolerances allowed, this seed would still be salable in the state. However, when the Weed Infested Materials Act is applied, this lot of seed would be suspended for sale. Thus keeping down the spread of this weed in our state.

We could cite many more examples such as these, but time will not permit our doing so. Again may I say, Weed Laws are important, and if we do the best we can with the laws and facilities at hand, much can be accomplished. Cooperation between states, uniformity in administrative policies, as well as uniform weed laws can certainly bring about a more effective enforcement program for the association as a whole.

1/ Oklahoma Department of Agriculture, Oklahoma City, Oklahoma

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WEED LAWS ARE IMPORTANT - SUMMARY OF PANEL

Chas. J. Gilbert 1/

After the splendid previous discussions concerning the weed laws of the various other states, and by Mr. Sanderson of our state, anything that I might now add would be anti-climactic.

It is obvious that the successes of the weed programs have had their foundations in weed laws upon which the leaders in research, education, industry, organization, and regulatory fields have built their programs.

Without adequate and carefully developed weed control legislation you cannot start a weed program; without a functioning and practical weed law you cannot continue to carry on the program; without such a law you can never even approach the proper completion of a program. Weed laws are important.

1/ State Weed Board, Brookings, South Dakota

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BANQUET ADDRESS

THE NORTH DAKOTA AGRICULTURAL COLLEGE

BATTLES WEEDS

H. L. Walster 1/

Here is a plant under suspicion. It persists where it is not wanted. It must be a weed. Eradication or at least control of a possible pest is sought. A specimen is sent to the Agricultural College. It is referred to a botanist. The botanist identifies this maverick of the field or garden and writes a letter to the inquirer telling what he knows about the weed and what he can recommend as practical measures for controlling it.

Every Land Grant College in the United States is annually deluged with numerous inquiries about weeds. This paper proposes to trace the record of the North Dakota Agricultural College in dealing with weeds.

Before we get into that subject an honest confession should be made, namely, that we still have plenty of weeds on the college farm including such noxious weeds as Canada Thistle, Sow Thistle and Quackgrass. Oh yes, our experimental plots are kept free from these perennial weeds altho they do become infested from time to time. That part of the farm used for production of feed and forage crops had become heavily infested with weeds before it was acquired by the College - - their control is still a matter of constant attention.

The NDAC now consists of the three divisions: Teaching, Research and Extension, each of which concerns itself with weeds.

When NDAC was established in 1891 two remarkably well trained botanists joined its staff: C. B. Waldron and H. L. Bolley. C. B. Waldron came to us from Michigan State College and Bolley from Purdue University. Both had pursued courses under excellent teachers. Both were imbued with the idea of service to the agriculture of a new and growing state. A younger brother of C. B. Waldron's, Lawrence R. Waldron soon joined his brother in North Dakota, graduated from the Agricultural College under the direction of his major professor, H. L. Bolley and by 1895 had joined the staff of the Botanical Department.

The record fails to show that the professional early agriculturists on the staff of the NDAC had much of any interest in weeds. The botanists grabbed the ball and kept it. In the discussion which follows an outline will be given of what they did.

The Botanists Teach College Students About Weeds

The first prospectus of the NDAC, issued in June 1891 announced that Prof. Bolley would lecture on "Weeds; Nature and Distribution". The first regular catalog of the College issued in May 1892 made a similar announcement, namely, that a course on "Weeds and their Distribution" would be offered to second year students. In the offerings for the school year 1905-06 students were offered a course on "A study of the characteristics of the seeds and seedlings of farm crops and weeds, their development, structure and function". This intensely practical course was offered primarly for sub-freshmen, short-year course in agriculture students, and winter short course students. Advanced students of regular college standing were offered that same year for the first time a course called Botany XIII: "On economic seed studies, seed grading, and elevator methods of grading and testing". By the school year 1909-10, Botany 8: "Seed analysis and classification" appeared in the catalog.

The many inquiries coming to the Agricultural College plus the leadership exerted by Prof. H. L. Bolley led to the passage by the Legislature of a Pure Seed Law in 1909, which law provided that the "Director of the North Dakota Agricultural College Experiment Station is hereby authorized to appoint a state seed commissioner", (Section 7 of Chapter 209 - 11th Legislative Assembly, 1909). That the Legislature wanted the director to name Professor Bolley as State Seed Commissioner is quite evident from the provisions of Section 9 of the same act - - which set forth that:

"The certificate of the botanist of the North Dakota Agricultural College Experiment Station at Fargo, giving the results of any examinations, analysis, or test made under the authority of said Experiment Station, shall be presumptive evidence of the facts therein stated".

Section 3 of this original seed act prohibited the sale of agricultural seeds containing any seeds of quackgrass, Canada thistle, sow thistle or dodder. It also provided that no more than a "reasonable trace" of some 38 other species would be unlawful. It is interesting to note that this first pure seed law prohibited sale of any agricultural seed containing more than a reasonable trace of sweet clover seed. The Legislature of 1927 amended the state seed law by removing the appointment of the State Seed Commissioner from the powers of the Director of the Experiment Station and placing it with the State Board of Administration. The appropriation for the enforcement of the act was made to the Agricultural College. In 1931 the seed act was amended again, and was entirely divorced from the Agricultural College except that the law provided that the headquarters, main offices and other principal operating facilities shall be located at the North Dakota Agricultural College at Fargo, North Dakota. In this 1931 revision and subsequently all legislative appropriations have been made directly to the "Seed Department of the State".

North Dakota law as set forth in the revised Statutes of 1943 classified certain weed seeds as "prohibited weed seeds" including in that category leafy spurge, field bindweed, perennial peppergrass and Russian knapweed. Listed as "primary noxious weeds" are quackgrass, Canada thistle, perennial sow thistle and dodder. Primary noxious weed seeds are by law defined as "the seeds of annual and perennial weeds which where established are difficult to control but which yield more readily to control by ordinary good cultural practices". In respect to the singling out of a group of weeds difficult to control but which will yield to good cultural practices one cannot help but believe that this is, in effect, a case of enduring the inevitable - - I am reminded of those famous four lines of Alexander Pope in his Essay on Man:

"Vice is a monster of so dreadful mien
As to be hated needs but to be seen
Yet seen, too oft, familiar with her face
We first endure, then pity, then embrace"

Law, it seems to me, continues to temporize with the weed problem as far as the farmer is concerned and to sedulously avoid any appearance of dealing harshly with publicly controlled or quasi publicly controlled lands, such as highways, railway rights of way, etc.

But to return specifically to teaching about weeds - - one of the signal advances in botanical science was the establishment of the concept of ecology by the Danish botanist Warming in 1895. This science, devoted to a study of the influence of environment on plants has been one of the most useful tools in the application of science to agriculture. In the school year 1947-48, the Botany Dept. of NDAC offered for the first time a course on the "Ecology and Control of Weeds".

Freshman students, enrolling in the School of Agriculture, NDAC get about two weeks of required instruction on weeds in their first course in Agronomy.

The course for freshmen is predicated on the fact that they have not yet had a course in botany hence it is necessarily given on a rather elementary level.

Research on Weeds

In June, 1892 there was published the Experiment Station's first systematic account of a group of weeds, "The Mustard Family" - - Bulletin 6 by Prof. C. B. Waldron(1). He described and pictured wild mustard, tansy mustard, treacle mustard (western wall-flower), false flax, shepherd's purse, penny cress (usually called Frenchweed, or fanweed), peppergrass and wormseed mustard. In a section on the Extermination of the Mustard's C. B. Waldron noted, appropriately with pungency: "The Mustard Family ceases to be a terror as wheat divides a part of his domain with hoed crops, meadows, and pastures. Alas and Alack! He posed a problem in division not yet solved in North Dakota."

Waldron also pointed out that the mustards have a quality that "so well enable the plants to take care of themselves in the battle of life that any precaution we can take to prevent them from first getting a foot hold becomes doubly necessary". This early study of the mustards closed with a frank recognition of the difficulties involved in weed control. Said C. B. Waldron: "It should be kept in mind that while it is very difficult and expensive to rid the land of weeds that have obtained a foothold, it is comparatively easy to keep the land free from weeds if all will unite in the effort. Since all may not be able to see the force of this, it may be necessary to clear their vision with a little wise and effective legislation upon the subject. If the present laws may be judged by their very imperfect results, all will agree that there is much need for further legislative action upon the subject of noxious weeds".

H. L. Bolley, Botanist to the station joined the fight against weeds in 1893 in a short Press Bulletin on the Russian cactus now called Russian thistle - - a plant which as Bolley pointed out is neither a cactus nor a thistle(2). A reprint of Bolley's Press Bulletin on "Russian Cactus" appears on pp 18-20 of the Station Director's Annual Report for 1894. Ever a fighter, Bolley led the fight against weeds for many years. With the help of Lawrence R. Waldron, then Assistant Botanist he published North Dakota Agricultural Experiment Station Bulletin 46 "A preliminary list of the Spermaphyta - - - Seed bearing plants of North Dakota in 1900"(3). This preliminary flora of the state had a double purpose. Said the authors: "Our purpose will be attained should our remarks make a few friends in each county of the state for a number of the valuable and beautiful native plants which are rapidly being destroyed by cultivation, or if we succeed in warning a like number against the pernicious weedy character of some of the introduced plants which are ever ready to follow in the wake of the careless plowman".

Here, my friends, are some of the warnings Bolley and Waldron sounded 54 years ago:

Frenchweed: "One of the worst weeds in the northwest"

Ball mustard: "Being introduced at the north, a bad type of weed"

Hare's ear mustard: "One of the worst forms of the mustard weeds"

Tumbling mustard: "Must eventually become one of the types of mustard to combat in cultivated fields"

Corn cockle: "Seeds are poisonous - - a bad weed in wheat"

Wild rose (Rosa blanda): "From the standpoint of cultivation and wheat culture the wild rose is one of the worst weeds".

Cocklebur: "This weed is a native of this state as yet it has not appeared as a troublesome one in cultivated areas. It needs watching as its eastern relative is very troublesome when once seeded"

Canada thistle: "This weed seems to thrive well in this state. It should receive close attention to prevent further distribution. The plant is not native but is rapidly invading from north and east".

Prickly lettuce: "This is a weed of the worst character . . . it would be worth millions of dollars per year to this state if it could be prevented from gaining a general footing"

Russian thistle: "This sharp or spiny leaved annual plant is neither a thistle or a cactus, but under dry, rather sterile conditions it develops into a troublesome weed. If there is sufficient soil moisture to develop a cereal crop, it need not give any trouble. In regions where it has occupied the land farmers must modify methods so as to give the regular crop the start"

Yellow pigeon grass or Yellow foxtail: "A very bad weed in cultivated ground"

Green pigeon grass or Green foxtail: "This and the last species (ie. yellow pigeon grass) probably reduces the yield of wheat in this state more than all other weeds combined. Thorough screening of seed grain will greatly reduce its capabilities to do injury"

Wild Oats: "A very bad weed in grain fields. The seeds usually fall early thus keeping lands under cultivation thoroughly seeded from year to year"

Quackgrass: "Apt to be a troublesome weed"

Wild barley: "A bad weed encroaching upon lawns and pastures. Of no agricultural value and injurious to cattle where fed as hay, the long sharp awns causing ulcerations"

Bolley and Waldron's 1900 list does not include several of the weeds now recognized as noxious weeds in the state, notably leafy spurge, field bindweed, and perennial sow thistle all three of which appear to have been introduced since 1900. Stevens (4) stated in 1922 that leafy spurge was "First found at Fargo in 1909". In the same publication, reporting upon the distribution of field bindweed, he said "not yet occupying any large areas of ground but found at several places across the southern part of the state". His comments on perennial sow thistle, also in the same publication, are "Introduced in the northeast corner of the state about 1900. Now common through the Red River Valley but more abundant in the northern half. More or less frequent west to the Soo line and occasional further but not yet known west of the Missouri River".

Whether or not northeastern North Dakota and the immediately adjacent northwestern Minnesota were the sole "ports of entry" of perennial sow thistle is not known but it is of interest, however, to note that the recent North Central States Weed Bulletin (5) shows a map of present distribution portraying the infestation of this weed in most of North Dakota, almost all of the eastern half of South Dakota, all of Minnesota, Wisconsin, and Michigan, northern Iowa and extreme northern Iowa.

Bolley, an ardent student of botany used many different methods to acquaint his clientile with weeds. To the preparation of the first Flora, and the beginning of an herbarium we must add the following from the Fifth Annual Report of the Director of the Experiment Station (1895):

1. Collection of weed seeds.
2. Studies on weed seed dissemination

The Fifth Annual Report contains Bolley's shrewd comments on a current proposal for the control of Russian thistle. He wrote: "A proper knowledge would give us a basis for a statement with regard to the value of attempting to fence against the encroachment of several of our worst weeds, which is quite loudly advocated by many, even to the enactment of laws and appropriations by the State for the purpose of fencing. The idea that fences could be of any lasting value in our struggles with such a weed as the Russian thistle does not seem well based but further facts are needed to support this assertion." If I may be permitted to digress a bit from a recital of the work of the NDAC I would like to give you a quick glance at the Russian thistle problem as viewed by the old--timers. The Bismarck Daily Tribune carried many stories about the Russian thistle in 1893, 1894, and 1895. Here are a few samples from that daily paper:

October 24, 1893 - - Editorial column. "Stutsman county farmers seem to be fully aroused to the danger of Russian Cactus. Pursuant to a numerously signed call a mass meeting of farmers, politicians and others met in the courthouse at Jamestown to devise ways and means to rid the country of this particularly noxious weed. Farmer E. T. Kearney who will be remembered as a member of the legislature of 1891 expressed himself in favor of an extra session of the legislature to provide for building a wire fence across the state to lodge the cactus as it blows northward."

November 28, 1893. "The citizens of the southeastern part of the state and the executive committee recently appointed by the governor are taking active interest in the matter of the extermination of the Russian Cactus".

December 28, 1893. "Cactus Memorial: The members of the cactus committee appointed by the governor have prepared a memorial to congress and sent it on to the governor for his signature. It will be signed as soon as the governor returns from Wahpeton and forwarded to Washington."

January 30, 1894. "The governor sends out the following communication anent the Russian Cactus . . . I am in correspondence with our senators and the United States Commissioner of Agriculture and am encouraged to believe that we will get a national appropriation; if so, with prompt action on the part of county officers we may be able to get rid of the cactus, the worst of all noxious weeds" . . . E. C. Shortridge, governor.

February 19, 1894. Head-lines of story on front page of the Bismarck Daily Tribune:
Russian thistle - Parties interested in the extermination of the weed heard by the Agricultural Committee. It has spread until it covers an area of seventy thousand square miles. A Great Northern official thinks it will prove worse than a grasshopper plague.

September 13, 1894. 10 inch column story - "The Russian Cactus. The pest seems to have renewed its lease on life, and will make trouble."

The Tribune quotes an interview with W. D. Swett published in the Fargo Daily Argus: "The vanguard of the invader is already north of Sheldon, with the fall winds it will make its appearance in our neighborhood . . . at Oakes the town is given over to it. Lamoure is gone with it. In the former town the streets are lined with it, the sidewalks run between hedges of it, the chinks of the sidewalk are fringed with it, the yards and vacant lots are matted with it."

January 10, 1895. From Governor Roger Allin's message to the legislature: "Russian Cactus" - "The attention of the legislative assembly doubtless will be called to the reports of damages being done by the rapid spread of what is commonly known as the Russian Cactus. It is a question that demands thorough investigation to determine whether it is expedient and constitutional for the state to undertake its eradication or to extend aid to the districts overrun by it".

February 15, 1895. The Russian Thistle Bill worked up by ex-U. S. Senator Casey.
Provisions: $30,000 appropriation to aid farmers who needed aid. A one mill tax to create a state thistle fund - - expected to raise $75,000. A commission called a Thistle Relief Board.

April 20, 1895 Governor Allin appoints two members of Thistle Executive Relief Board as provided for Senate Bill 125 (probably meant Senate Bill 126. HLW).

June 18, 1895. To Combat Thistle. "The Farmers Russian Thistle Protective Association is not yet a corporation, according to the St. Paul Pioneer Press it is simply an association of St. Paul business men who have come to a knowledge that something must be done for the farmer in this matter, and to understand that the way to combat the enemy is to bring all the best thought and experience in the country to bear on the subject".

July 30, 1895 Headlines: "'Regarding Cactus' . The cactus commission finishes its trip through the district affected by the weed. The feeling of the farmers is that United individual effort will eradicate it. The commission will probably make a trip into the frenchweed district - Ere Long" This writer has never yet been able to find out just how the commission spent that $30,000 - - maybe the capitol fire settled that question.

Stevens (6) made an especially noteworthy contribution to our knowledge of perennial sow thistle in Bulletin 181 issued in August 1924. In this thorough study he reviewed the botanical relation of the plant, the two forms of the plant, its world-wide distribution; its distribution in the United States and Canada, etc. He then covered in detail its vegetative habits; its flowering habits; the germination of its fruits, the growth of seedlings - - in short he presented botanical science with a detailed life history of this noxious weed.

Stevens (7) followed up Bulletin 181 with Experiment Station Circular 32 which stressed prevention, eradication and control of perennial sow thistle.

The Botany Department of the North Dakota Agricultural Experiment has carried for several years an important research project on the life histories of the more mischievous weeds. These researches have culminated in the following comprehensive bulletins:

Bulletin 181. "Perennial Sow Thistle - - Growth and Reproduction", O. A. Stevens, August 1924.

Bulletin 266. "Leafy Spurge -- Life History and Habits", H. C. Hanson and Velva Rudd, 1933. In an article in the Dakota Farmer (46:613) in 1926 Stevens marked field bindweed and leafy spurge as "weeds that will bear close watching". In an earlier contribution to

the Dakota Farmer (44:582) in 1924 Stevens had announced the appearance of "A new weed - - leafy spurge".

Bulletin 292. "Russian Knapweed and Perennial Pepper-grass", E. A. Helgeson, 1940. Bulletin 292 treats of two weeds, both first reported for North Dakota by O. A. Stevens in a contribution to the Bulletin of the Torrey Botanical Club in 1922, (49:93-105). Stevens had predicted as early as 1912 that perennial pepper-grass would become a weed in this State. It was reported in 1918.

Bulletin 326. "Russian Thistle - - Life History and Growth", O. A. Stevens, 1943. This ranks with Stevens' comprehensive study of the Perennial Sow Thistle.

Bulletin 346. "Studies on Wild Buckwheat", O. A. Stevens, May 1947. Describes the characteristics of the plant and relates its encroachment and persistence to crop rotations practiced.

More inquiries reach the college about the eradication and control of wild oats than of any other weed. The following are the most-recent contributions to this age-old problem:

Helgeson, E. A., "Wild Oats control methods followed in the United States". Presented at the joint meeting of the North Central Weed Control Conf. and the Western Canadian Weed Control Conf., December 1952, p. 25.

Stoa, T. E., Helgeson, E. A., and Conlon, T. J. "Wild Oats - - Can They Be Controlled". North Dakota Agricultural Experiment Station Bimonthly Bulletin 15 (5):216-223, May - June 1953. This is a carefully reasoned study relating the practical control of wild oats to the problem of dormancy of the seed. Mention will be made later in this paper of an extension circular on Wild Oats.

Chemical Control of Weeds

Bolley made his first experiments on chemical weed control in the spring of 1896 by using a solution of corrosive sublimate to destroy English Charlock (9). In the spring of 1899 he had his attention called to some work in France in destroying thistles and mustard by the use of iron sulphate and copper sulphate solutions. Following up this suggestion he tried 10% copper sulphate spray solution on a wheat crop about 3 to 5 inches high containing several varieties of annual weeds. In this first paper on the subject Bolley successfully destroyed many broad leaved weeds but had some tip-burn of wheat leaves in a few cases. This first paper published in 1899 reports trials on copper sulphate only - - although in its last sentence the author adds "Later work with other chemicals gives further assurance that the idea is well founded". Whenever Bolley got hold of a fruitful idea he pursued it vigorously. Following up his 1899 publication the following came from his pen:

"Spraying to kill weeds in wheat and oat fields". Press Bulletin No. 9, April 1903

"Types of spraying apparatus and machines which are essential for weed destruction by means of chemical sprays", Press Bulletin No. 24, October 1907

"Means of eradicating dandelions in parks, lawns roadsides and meadows", Press Bulletin 26, October 1907. (This was re-issued in revised form in July 1908.)

"On the use of Chemical sprays for destroying mustards, kinghead and other weeds in cereal grain fields", Press Bulletin No. 27, January 1909 (first issued in October 1907).

"Canada Thistle; means of holding in control", Press Bulletin No. 28, October 1907.

"Weeds and Methods of Eradication", weed control by means of chemical sprays - - Bulletin 80, March 1908

Space does not permit a complete record of the many contributions to our knowledge about weeds made by the Station Staff but I must refer you to a bibliography on weeds which Dr. Stevens (8) himself compiled covering the years - 1892 - 1942 which was published in the Station's Bimonthly Bulletin: 5 (5):30-35, 1943. This lists 53 contributions by Stevens, 26 by H. L. Bolley, 6 by L. R. Waldron, and 9 by E. A. Helgeson. Some 121 papers are listed in this bibliography which closed with 1942. In the 12 years which have followed Dr. Stevens and Dr. Helgeson have added many more contributions.

Weed Control Activities by The Extension Service

The first weed to get the Extension Service of North Dakota excited was the perennial sow thistle, and quite properly they have continued to remain excited about it. The first Extension publication on the Perennial Sow Thistle appeared in March 1919 under the authorship of W. R. Porter, then Superintendent of Demonstration Farms of the Experiment Station and O. A. Stevens, then seed analist for North Dakota Pure Seed Laboratory - - the title was Circular 18, "Sow Thistle and Weeds of Similar Habits". For those best caught by a big colored picture, J. W. Haw, then County Agent in Cavalier County and O. A. Stevens prepared Extension Poster 12 on the "Perennial Sow Thistle". Three years later, or in 1922, Sidney W. Hooper, Extension Editor followed up the attack with Extension Circular 47 - - "Fight the Sow Thistle". In 1937 the Extension Service re-printed Experiment Station Bulletin 243 on "Weeds" by O. A. Stevens issuing it as Extension Circ. 156. It, of course, contained a section on the perennial sow thistle. It is probably fair to state that interest in the control of perennial sow thistle lagged in the dry '30's but the greater rainfall of the '40's renewed interest with the resultant publication in 1945 of Extension Circular A-88 on "Control of Perennial Sow Thistle" by E. A. Helgeson.

Because field bindweed and wild morning glory are commonly confused the Extension Service printed an unnumbered Extension Poster in 1938 titled "Which is Which: Field Bindweed or Morning Glory". This poster appeared in color as did also another poster entitled "Destroy Leafy Spurge - - Field Bindweed or Creeping Jenny", which the Extension Service published at the same time. With the advent of the '50's interest in chemical control of weeds surged upward again, Extension Circ. A-194 appearing in 1953. Prepared by E. A. Helgeson, Station Botanist, and R. B. Widdifield, Extension Agronomist, Circ. A-194 on "Chemical Control of Perennial Weeds" recommends chemical control methods for perennial sow thistle, and other weeds. In the same year Wayne J. Colberg, Extension Entomologist and R. B. Widdifield, Extension Agronomist, prepared an unnumbered "Guide for Mixing Insect and Weed Control Chemicals".

Other recent short Extension Circulars on Weeds are:

Ext. Circ. A-89. "Suggestions on control of Canada Thistle" - compiled by E. A. Helgeson, Botanist, Experiment Station, November 1945.

Ext. Circ. A-90 "Control of Quackgrass" - compiled by E. A. Helegson, Botanist, Experiment Station, November 1945.

Ext. Circ. A124 "Controlling Wild Oats". T. E. Stoa, Agronomist, Experiment Station, January 1948.

Ext. Circ. A125 "Destroy Mustard". T. E. Stoa, Agronomist, Experiment Station, January 1948.

Ext. Circ. A178 "Leafy Spurge Control". Prepared by E. A. Helgeson, Botanist, Experiment Station, D. E. Kratochvil, Agronomist, U.S.D.A. and R. B. Widdifield, Extension Agronomist.

Ext. Circ. 192 "Prohibited Noxious Weeds of North Dakota and their control". E. A. Helgeson, Botanist, Experiment Station and R. B. Widdifield, agronomist, Extension Service, issued June 1953.

This last circular is the most recent Extension foray against weeds and it contains excellent plates furnished through the courtesy of the South Dakota Extension Service which portray in color the perennial sow thistle, Canada thistle, leafy spurge, field bindweed, Russian knapweed and perennial pepper-grass. Printer's ink, will, of course neither control nor eradicate weeds, but like Ole's 14th cup of coffee it helps keep an easily apathetic public awake to the damage done by weeds, and to considerable extent provokes that same public to action. May I emphasize that this paper has not tried to review the field work in extension which covers eradication demonstrations, seed cleaning, seed purity, etc.

Lest I be misunderstood let me here and now urge all members of the conference to keep the presses rolling, the hoes chopping, and the sprayers spraying for weeds still possess our fields and your fields even as they possessed those Roman fields about which the poet Virgil wrote nearly 2000 years ago:

> "Tough thistles choked the field and kill'd the corn
> And an unthrifty crop of weeds was born
> There Burrs and Brambles, an unbidden crew
> Of graceless guests, th' unhappy fields subdue;
> And Oats unblest, and Darnel domineers,
> And shoots its head above the shining ears".

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(4) Stevens, O. A. North Dakota Weeds. Bulletin 162, Agricultural Experiment Station, North Dakota Agricultural College, June 1922

(5) Buchholtz, K. P. et al. Weeds of the North Central States. Illinois Agricultural Experiment Station Circular 718 (N. C. Regional Pub. No. 36), Feb. 1954.

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(7) Stevens, O. A. The Sow Thistle. North Dakota Agricultural Experiment Station Circular 32, 1926

(8) Stevens, O. A. (compiler) Weeds - Publications of the North Dakota Agricultural Experiment Station in Weeds. North Dakota Agricultural Experiment Station, Bimonthly Bulletin: 5 (5): 30-35, May 1943

(9) Bolley, H. L. The destruction of weeds in cereal crops by means of solutions of chemicals sprayed upon the foliage. Proc. of the 20th. annual meeting of the Soc. for Promotion of Agricultural Sciences Pp. 107-109, 1899.

1/ Formerly Dean of Agriculture and Director of Agricultural Experiment Station, North Dakota Agricultural College, Fargo, North Dakota.

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PRESENTATION OF AWARDS

A. Industry Awards for Outstanding Weed Control Work. Remarks by K. A. Boss, Mutuals Dealers Wholesale Inc., St. Paul, Minn.

Extension Worker Award

Henry Ness. Mr. Ness, formerly County Agent of LaMoure County, North Dakota, is now County Agent of Cass County with offices at Fargo, N. Dak. Mr. Ness has conducted 19 weed meetings and five tours to show the results of weed spraying in which he had over 560 people in attendance. He prepared 18 news stories which were published and conducted four training schools. He calibrated 30 field sprayers.

He worked in close cooperation with 4-H Club members and chemical dealers and he worked with the County Crop Improvement Association on an extension drill box survey as well as educational meetings for farmers on weed control.

Mr. Ness has assisted in the County Roadside Spraying Program which was organized in 1950 and carried on each year since.

Regulatory Award

Otto H. Kruse. Mr. Kruse is from Route 4, Fairmont, Minnesota and represents Martin County. He was selected as being the outstanding Regulatory worker and

as part of his work he conducted 26 weed meetings, 14 tours to inspect week work, wrote 46 news stories and presented 24 radio programs. He held 50 training schools, made 761 individual farm contacts and calibrated 50 sprayers.

He held numerous visits with chemical dealers, state and county highway personnel as well as the utility companies and other state agencies.

Among the work he accomplished was 351 weed inspections for weed seed. He aided in the spraying of 245 acres of railroad right-of-way and highway department property. He cooperated in the cleaning of 250,800 bushels of seed. There were 69,520 acres of grain, including corn, sprayed in the county and 8500 acres of non-crop land.

He worked in close contact with the State Weed Inspector's office, the District Supervisor, as well as County Commissioners, County Extension Office, and kept in constant touch with Town Board members and Assistant Township Weed Inspectors, including Village Mayors, and in close cooperation with the County Engineer's office. He carried on a program of post harvest spraying for Canada thistle.

B. Honorary Membership Award. Remarks by R. E. Nylund, University of Minnesota, St. Paul, Minn.

After careful consideration, the honorary memberships committee chose one man as being eminently qualified to receive the Honorary Membership Award this year. When the committee made their choice I am fairly sure that none of them knew that the man they chose has his roots in this state of North Dakota, but it is rather appropriate, I think, that this happens to be true. It is, in fact, quite possible that our man's choice of a career in weed research is directly related to his being born and raised in North Dakota for in his youth he must surely have heard of and been exposed to the teachings of Professor Bolley, one of our pioneers in weed control research, who was very active here at that time.

Arthur Lawrence Bakke. The man of our selection went to Iowa State College where he received his Bachelor of Science degree in 1909 and his M. S. degree in Botany in 1911. Except for time out to win his doctorate at the University of Chicago in 1917, to study at the Desert Laboratory of the Carnegie Institute in 1913-14, and to carry on special research at Copenhagen and at the Central Experiment Station at Stockholm, Sweden in 1929, our candidate has been on the staff of Iowa State College continuously since 1910. He has been active in weed control research since 1910 and has devoted essentially all his time to such research since 1929. He was in charge of the weed control experiment stations at Hawarden and at Cherokee, Iowa from 1930 to 1945.

The titles of some of his early papers attest to his contributions in weed control research. For example, in 1922, a paper entitled: "Effects of Weeds Upon Crop Production". Later papers include: "Leafy Spurge", "Control of Leafy Spurge", "Soil Moisture Relationships of European Bindweed Growing in Corn", "Relation of Root Reserves to Control of European Bindweed", etc. etc.

In our conference he has been an active participant, having served as chairman of the research committee and as chairman of several other committees from time to time.

Important as his contributions to our knowledge of weeds and their control have been and as important as his services to the conference have been, I feel that the recipient of our award tonight deserves this honor for another less tangible but even more important reason.

Beginning as early as 1910 and for years and years when there was little interest in weed control research, probably even less support, and certainly none of the present-day glamour of such research, this man was keeping alive and was promoting among his students and among farmers of his state the idea that weeds are insidious outlaws that were robbing the farmer of part of his crop and thus must be destroyed.

It seems to me that the rapid acceptance by farmers of the new methods of weed control that came with the advent of 2,4-D is due in no little degree to the lifetime campaigns of education as carried on by men like the recipient of our honorary award tonight - Dr. Arthur Lawrence Bakke.

I would like to read the citation as given on this scroll: "In recognition of outstanding contributions to progress in weed control, for a lifetime of devotion to weed control research and education, and for providing leadership and inspiration for others in this field, the North Central Weed Control Conference presents this scroll at Fargo, North Dakota on the 7th day of December, 1954."

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CONTROL OF WEEDS IN SPRING SEEDED ALFALFA

Paul F. Sand 1/

Alfalfa was seeded April 23, 1954 on soil treated with lime, 40 lbs/A. of available phosphate, and 35 lbs/A of nitrogen. The alfalfa seed contained about 10% weed seed including yellow foxtail, kochia and ragweed. A fairly uniform crop of volunteer green foxtail emerged from seed in the soil. Chemicals were applied at five dates of treatment. Three and 6 lbs/A of CIPC and 5 and 7 lbs/A of TCA applied at pre-planting; 1, 2 and 4 lbs/A of Dalapon, 3, 4, 5, and 6 lbs/A of dinitro, 5 and 7 lbs/A of TCA and 1/4 and 1/2 lbs/A of Silvex ester were applied at the pre-emergence stage; 1, 2, and 4 lbs/A of Dalapon, 1 and 1.5 lbs/A of dinitro, 5 and 7 lbs/A of TCA and 1/4 and 1/2 lbs/A of Silvex ester were applied at the emergence, 1 week after emergence and 4 weeks after emergence of the alfalfa. No weeds had emerged at the time of pre-planting treatment. The chemical was applied and worked into the soil. A few scattered plants of foxtail were emerging at the time of the pre-emergence treatment and about the same amount was present at the emergence stage. At the time of treatment of the 1 week after emergence stage the alfalfa had the first unifoliate leaf and a good stand of foxtail was present with 2-3 leaves. Four weeks after emergence the alfalfa was 3 to 4 inches tall and the grasses 3-4 inches tall.

Stem counts of alfalfa, weedy grasses and broadleaf weeds were made the last week of June from five eight square foot quadrats in each plot. Yield tests were made on September 1, on most of the treatments that gave good weed control.

Results

Chloro IPC: as a pre-planting treatment did not give satisfactory control of weedy grasses. The six pound rate gave a 44 percent reduction in stand of the alfalfa.

Dinitro: did not give satisfactory weed control at any rate of application or stage of growth. It reduced the stand of alfalfa considerably at the pre-emergence and emergence stage of growth as shown in Table 2.

Silvex: at 1/4 and 1/2 pound per acre did not give weed control at any stage of growth but reduced the stand of alfalfa in all stages of growth.

TCA: gave good control of grass with practically no reduction in stand of alfalfa at any rates or dates of treatment. Pre-planting and pre-emergence stages gave poorest control of weedy grasses giving from 32 to 45% control. Emergence, 1 week after emergence and 4 weeks after emergence treatments gave 55 to 93% kills of weedy grasses with the 4 week after emergence treatment giving the poorest kill. However, grasses remaining in these plots were severely stunted and did not interfere with establishment of the alfalfa. Yields of grasses from these three dates of treatments were reduced significantly at the 5% level at the five pound rate at emergence and 1 week after emergence stages and significantly at the 1% level for all three stages at the 7 pound per acre rate.

Stands of alfalfa were affected very little by TCA. Both the 5 and 7 pound rates showed a slight reduction in stand at some stages but the reductions were not significant. Yield from the emergence and 1 week after emergence stages at both 5 and 7 pounds per acre gave increases in yields that were significant at the 5% level.

Dalapon: was used at four stages of growth, pre-emergence, emergence, 1 week and 4 weeks after emergence at 1, 2 and 4 pounds per acre. The pre-emergence stage did not give any weed control, nor did it have any effect on the stand of alfalfa. The emergence, and 1 and 4 weeks after emergence stages gave good control of the grass, however, the stands of grass were not reduced as much as they were by the TCA treatments at these stages. The reduction in stand of grass at the emergence and 1 week after emergence stages was greater than the same treatments at the 4 weeks after emergence stage. Yields taken September 1, show that in spite of this the 4 weeks after emergence treatment gave superior weed control to the 1 week after emergence treatment by reducing the pounds per acre of grassy weeds considerably more than the 1 week after emergence treatment. Yields of grasses were reduced significantly at the 5% level by two pounds per acre of dalapon at the 4 weeks after emergence stage and 4 pounds per acre at the 1 week after emergence stage. Four pounds of dalapon at the 4 weeks after emergence stage reduced the yield of grasses significantly at the 1% level. A thick stand of fall panic grass (Panicum dichotomiflorum) made a heavy growth in some plots. Since the latest treatment (4 weeks after emergence) gave the best control it appears that much of the fall panic grass probably came up between the 1 week after and 4 weeks after emergence treatments. This grass accounts for most of the weedy grass material in the yield tests. Yield tests were only made from superior treatments.

Yields of alfalfa were increased in direct proportion to the amount of weed control. TCA at 5 and 7 lbs/A at emergence and 1 week after emergence and dalapon at 4 lbs/A at 1 week and 4 weeks after emergence gave yields significantly greater than the check at the 5% level. The check yielded 642 lbs/A while these treatments gave yields 800 to 1200 lbs/A greater than the check. Dalapon at 1 and 2 lbs/A gave practical control of foxtail at the emergence, 1 week after and 4 weeks after emergence treatments and the alfalfa was able to establish itself well, making it more capable of competing with the heavy growth of fall panic grass which appeared in August and September. The heavy production of fall panic grass was probably due to the heavy rainfall in August which totaled 10 inches.

Table 1. Stand of weedy grass plants per 40 square feet. June 24, 1954. Average of four replications.

Treatment	Rate lb/A	Pre-Plant.	Pre-Emerg.	Emergence	1 week after Emerg.	4 weeks after Emerg.
CIPC	3	218				
	6	225				
TCA	5	176	193	54	33	101
	7	157	193	26	19	127
Dalapon	1		295	122	124	140
	2		233	98	87	205
	4		287	94	73	166
Dinitro	1			277	224	284
	1.5			258	212	277
	3		303			
	4.5		346			
	6		242			
Silvex	1/4		358	278	265	264
	1/2		298	271	262	321
CK						284

Table 2. Stand of alfalfa plants per 40 square feet. June 24, 1954. Average of four replications.

Treat.	Rate lb/A	Pre-Plant.	Pre-Emerg.	Emergence	1 week after Emerg.	4 weeks after Emerg.
CIPC	3	267				
	6	176				
TCA	5	310	281	289	269	350
	7	282	273	267	304	298
Dalapon	1		312	307	326	351
	2		422	311	312	317
	4		314	228	257	380
Dinitro	1			196	251	281
	1.5			153	266	215
	3		209			
	4.5		154			
	6		146			
Silvex	1/4		160	81	171	177
	1/2		57	88	127	93
CK				317		

Table 3. Yield of weedy grasses in lbs/A. September 1954. Average of four replications.

Treatment	lbs/A	Emergence	1 week after Emerg.	4 weeks after Emerg.
TCA	5	819*	984*	1096
	7	599**	634**	630**
Dalapon	1		2511	1652
	2		1475	843*
	4		965*	390**
Check			1900	

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.

Table 4. Yielf of alfalfa in lbs/A. September 1954.
Average of four replications.

Treatment	lbs/A	Emergence	1 week after Emerg.	4 weeks after Emerg.
TCA	5	1412*	1340*	1280
	7	1605*	1641*	1151
Dalapon				
	1		996	984
	2		884	1214
	4		1431*	1826*
Check		642		

*Significantly different from the check at the 5% level.

SUMMARY

CIPC, Dinitro, and Silvex did not give satisfactory weed control. Some reductions in stands of alfalfa resulted from some of these treatments.

TCA gave good control of grass at 5 and 7 lbs/A at emergence, 1 week after emergence, and 4 weeks after emergence without injury to the stand of alfalfa.

Dalapon did not give any weed control as a pre-emergence treatment. One, 2, and 4 lbs/A at emergence, 1 week after emergence and 4 weeks after emergence gave sufficient control of grassy weeds so they did not interfere with establishment of alfalfa during June. However, the 4 weeks after emergence treatments were superior to the earlier treatments because more weeds had emerged by that time. The stand count of grassy weeds is higher at the 4 weeks after emergence treatment but the yield of grass in September is less on these plots.

1/ University of Nebraska, Lincoln, Nebraska

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THE CONTROL OF GRASSES IN ESTABLISHED ALFALFA WITH DALAPON

J. H. Davidson 1/ and F. W. Slife 2/

The control of undesirable grasses in alfalfa may be a problem when alfalfa is grown for hay, pasture, seed or dehydration. The recent availability of grass controlling herbicides affords an opportunity to control many of the unwanted grasses in alfalfa fields yet not damage the alfalfa. This paper deals specifically with the control of Giant Foxtail (Setaria faberii), Downy bromegrass (Bromus tectorum), Kentucky bluegrass (Poa pratensis), and quackgrass (Agropyron repens). Control as used in this discussion does not always imply kill of the grasses. In the case of the perennial species, suppression of grass growth may occur to a degree that reduces or eliminates the grass problem.

Materials and Methods

Dalapon sodium salt (68% acid equivalent) was the material used in all experiments. In the tests against giant foxtail the sprays were applied at the rate of 20 gallons per acre with an experimental plot sprayer. The downy bromegrass and perennial grass suppression experiments were applied with a garden type tractor sprayer, delivering 30 gallons of spray per acre at 40 psi. Grass control ratings were obtained by observation. Alfalfa yields were taken by harvesting 25 sq. ft. areas in the treated plots and converting fresh weight to dry weight.

Results

Giant Foxtail: Tests for the control of giant foxtail in alfalfa were conducted in the vicinity of Urbana, Illinois. An alfalfa field known to be infested with giant foxtail was sprayed at three different dates: 1) April 22 when the alfalfa was about eight inches tall, 2) June 10 immediately after the first cutting of hay, and 3) July 15 immediately after the second cutting of hay. The concentrations of dalapon used and the foxtail control ratings taken 3 weeks after application are shown in Table I.

Table I. Percent Foxtail Control In Alfalfa From Applications of Dalapon Sodium Salt Made: 1) In Spring Prior to Alfalfa Growth, 2) Immediately After First Cutting, 3) Immediately After Second Cutting. 1954.

Treatment	(lb. per Acre)	% Foxtail Control Dates of Application April 22	June 10	July 15
	3	45		
	5		100	85
Dalapon (acid equivalent)	6	75		
	7.5		100	95
	9	100		
	10		100	100
Untreated		0	0	0

Table II. Yield of Alfalfa From Plots Treated With Dalapon Sodium Salt For Control of Giant Foxtail. 1954.

Treatment	Tons of Alfalfa Per Acre (Dry Weight) Dates of Spraying April 22			June 10		July 15
lb./Acre	1st Cut.	2nd Cut.	3rd Cut.	2nd Cut.	3rd Cut.	3rd Cut.
3	1.17	.61	.99			
5				.86	1.03	1.03
Dalapon 6 (A.E.)	1.11	.63	1.00			
7.5				.81	1.03	1.04
9	.77	.51	.85			
10				.84	1.02	1.03
Untreated	1.19	.65	1.00	.79	1.03	1.05

Table III. Downy Bromegrass Control From Early Spring Applications of Dalapon Sodium Salt. 1953

Treatment	(lb. per Acre)	% Downy Bromegrass Control Application Dates March 20	April 8
	3	90	85
Dalapon (Acid equivalent)	6	95	95
	9	100	100
Untreated		0	0

Table IV. Daily Rainfall During The Months of May, June, July 1954. Bloomingdale, Michigan.

May

Day	2	3	4	5	9	11	27	28	29	30
Rainfall	.16	.03	T	.02	.17	T	.11	.19	.09	1.00

June

Day	1	2	3	4	10	14	16	17	18	20	22	23	26
Rainfall	.96	.02	1.17	.30	.04	.04	.01	.40	T	.65	.48	.03	.22

July

Day	3	6	7	10	11	21	28	29	31
Rainfall	.61	.30	1.04	.19	.05	.08	T	.32	.02

The foxtail control was poor from the lower rates of the April 22 treatment because most of the foxtail seed had not germinated. Control was better at the higher rates which may be explained by the fact that there probably was enough chemical in the soil to act as a pre-emergence spray.

The June 10 application was ideal. Complete control of Foxtail was obtained at all rates. This test indicates that lower rates might be satisfactory when properly timed. The excellent control obtained from this application is probably due to the fact that all the foxtail seed had germinated and was in a stunted condition due to the competition of the alfalfa. Foxtail control from the third spraying date was less effective because the foxtail plants were more mature and the leaves had been harvested along with the alfalfa.

The effects of the above treatments on the yield of alfalfa are shown in Table II.

These data indicate that the highest rate of dalapon on alfalfa foliage applied April 22 when the alfalfa was about eight inches tall may have caused injury and reduced yield. Later applications applied immediately after harvest on alfalfa with little or no foliage resulted in no yield reduction.

Downy Bromegrass: Tests for the control of Downy bromegrass were conducted in southwestern Michigan in an alfalfa field of moderate vigor and considerable grass competition. Downy bromegrass is of rather spotty occurrence but frequently becomes a serious problem in certain alfalfa fields. Rains in September and October favor germination of the seeds in the fall. This is followed by vigorous growth early in the spring.

Limited applications of dalapon were made in 1953 at 3, 6, and 9 pounds per acre March 20 and April 8. At the earlier date there was very little alfalfa foliage showing. The small amount of foliage that had emerged was partially protected from the spray by the dead top growth from the preceeding season. Although the second date of application was almost 3 weeks later there was not a great deal of difference in the development of the alfalfa. Table III shows a rating made on May 27 of the downy bromegrass control obtained from these treatments.

Yield records of the alfalfa in this field were not taken. Growth of alfalfa in the 3 and 6 pound per acre plots appeared normal from both application dates. The alfalfa foliage on the 9 pound per acre plot applied April 8 showed a trace of marginal leaf injury two weeks after application. Later this injury was difficult to find.

An interesting observation made from this test was the effect these single treatments had on Kentucky bluegrass and quackgrass. Up until the time the alfalfa was first cut the growth of these perennial grasses was suppressed so there was very little grass in the alfalfa. Soon after the first alfalfa cutting the bluegrass and quackgrass resumed growth. At the time of the second cutting there was as much grass growth in the treated areas as in the untreated.

Kentucky Bluegrass and Quackgrass: The suppressing effect of dalapon sodium salt on Kentucky bluegrass and quackgrass was investigated further in 1954. A five year old alfalfa field of moderate vigor in southwestern Michigan was used for these tests. The stand of alfalfa was rather light with considerable quackgrass, bluegrass, orchard grass and a small amount of downy bromegrass growing over the entire field. Repeated applications of dalapon sodium salt were made beginning early in the spring prior to alfalfa growth. Additional treatments on the same plots were made immediately after each alfalfa cutting.

Rain fell on the following days as shown in Table IV.

Table V shows the total yield of hay from five replicated plots of each treatment. The weight and per cent alfalfa contained in the total hay samples are also shown.

The alfalfa was showing a moderate amount of new growth and foliage on April 13, at the time of the first application. This was reflected in reduced total hay yields and amount of alfalfa from the 8.2 lb. per acre rate of dalapon in comparison with the 4.1 lb. per acre treatment. Unfortunately this field was too wet to spray earlier. The second application applied on the same plots immediately after cutting did not show any injury even from the highest rate.

These preliminary results indicate that it may be possible to increase the percentage of alfalfa yet not reduce total hay yield by suppressing grass growth in fields where undesirable grasses are giving the alfalfa considerable competition. Yields obtained from the second cutting indicate the possibility of increased total hay and alfalfa yields when undesirable grass growth is suppressed from the beginning of the season.

The fact that grass control was obtained from sprays applied immediately after cutting when very little grass foliage was present indicates that absorption of dalapon by grass roots may occur when adequate soil moisture exists.

Table V. Total Hay Yield and Amount of Alfalfa Produced Following Two Sprays of Dalapon Sodium Salt.

	Dry Weight - Tons per Acre					
	1st Cutting 6/16/54			2nd Cutting 8/13/54		
Treatment lb./Acre	Total Hay	Alfalfa only	%Alfalfa by weight	Total Hay	Alfalfa only	%Alfalfa by weight
4.1	1.69	1.18	69.8	1.43	1.21	84.6
Dalapon 6.1 (A.E.)	1.22	.87	71.3	1.36	1.19	87.5
8.2	1.16	.76	65.5	1.41	1.22	86.5
Untreated	1.59	.30	18.9	.61	.26	42.6

Spray application dates April 13, 1954 - June 17, 1954

Summary

The preliminary tests described above indicate the possibility of grass control in established plantings of alfalfa. Properly timed sprays of dalapon sodium salt at concentrations ranging from four to ten pounds acid equivalent per acre may be used on established stands of alfalfa.

Downy bromegrass may be controlled by early spring applications of four to six pounds dalapon per acre. Applications made prior to new growth of alfalfa in the spring are safest. Established alfalfa with only a small amount of new growth will tolerate the lower rates of dalapon.

Giant foxtail may be readily controlled by applications of four to eight pounds dalapon per acre applied immediately after the first cutting. Delaying the spray application until alfalfa is showing new growth increases the possibility of injury.

Certain perennial grasses such as quackgrass and Kentucky bluegrass may be suppressed by two or three repeated applications of four to six pounds dalapon per acre. Such treatments do not kill the perennial grasses but their suppression results in improved alfalfa growth due to reduced competition. These sprays should be timed so as to contact a minimum of alfalfa foliage. The first application should be made in early spring before new alfalfa growth appears. The second and third applications should be made immediately after cutting.

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MCP, DNBP, 3,4-D AND 2,4-D AS HERBICIDES ON ALFALFA SOWN IN OATS

Paul W. Santelmann 1/ and C. J. Willard 2/

Seedling legumes are initially slow-growing plants and, consequently, are poor competitors. During this initial period of slow growth, many weeds have opportunity to outgrow them. These weeds that appear in new seedings of legumes may choke out, or seriously damage, the young legume plants.

Many methods are used to control these weeds with as little damage to the legume stand as possible. One of the most prevalent is the use of so-called "nurse" crops, which are generally small grains that grow rapidly and replace the weeds as competitors of the legumes. Another method is the use of chemical herbicides, either with or without the companion crop. Many compounds have been tried for this purpose and some have been found fairly satisfactory. The legumes are fairly susceptible to the substituted phenoxy acid compounds except under very special conditions. Other chemicals that have been tried, and are recommended in some areas, are trichloroacetic acid, various dinitro compounds and isopropyl-N-phenyl carbamate and its derivatives.

Studies in 1953 and 1954 compared various herbicides, at different rates and times of application, for their efficiency in stunting or killing the weed competitors and not harming the oats or the undersown alfalfa and red clover, thus increasing the chances of securing satisfactory establishment of the forage legumes. The primary purpose of this experiment was to compare the two phenoxy compounds, 2,4-D and MCP, in their effects on legumes and oats.

A mixture of 10 pounds of alfalfa and 4 pounds of red clover was seeded with 6 pecks of oats per acre in early April. Turnips in 1953 and leaf lettuce in 1954 were sown as weeds. Triplicated plots were treated at one of 3 stages. In 1953 these stages were:

1. Pre-emergence.
2. Oats with 3 true leaves - no canopy formed.
3. Oats in the jointing stage.

In 1954 the following stages were used:

1. Oats with 3 true leaves - no canopy formed.
2. Oats fully tillered.
3. Oats in the boot stage.

The chemicals used were amine MCP (1/8 to 1 lb/A); amine 2,4-D (1/8 to 1 lb/A); isopropyl ester of 2,4-D (1/8 to 1/2 lb/A), DNBP (1 and 2 lb/A); TCA (5 and 10 lb /A) was used in 1953 but not in 1954; and in 1954 3,4-D (1/4 to 1 lb/A) was used. All chemicals were applied in 10 gallons of solution per acre except DNBP and TCA which were applied in 40 gallons.

Only TCA treatments at the earlier stages harmed the oats, the other herbicides did not. However, when any of the compounds were applied at the boot stage, the yields of oats were significantly reduced below the yields of the earlier stages. However, no treatment significantly reduced the yields below those of the untreated checks except for TCA at the early stages.

The phenoxy compounds killed the turnips and lettuce sown as weeds. The TCA in 1953 did not harm the turnips, and the DNBP killed the lettuce at the earliest stage in 1954 but only about 1/2 of it at the later stages.

The turnips planted as weeds in 1953 resulted in a very heavy weed infestation and a resulting reduction in the legume stand. Therefore, there was a heavy canopy over the legumes early in the year and the legumes were protected when sprayed. Consequently, the stands of the MCP, 2,4-D and DNBP treated plots were much better than those of the untreated plots. Also, due to the heavy canopy, rates of MCP and amine 2,4-D up to 1/2 pound per acre did not damage the legumes. DNBP injured the legumes only when used at the last stage.

Hay was harvested from the 1953 plots during the early summer of 1954. It was found that the yields from the MCP and amine 2,4-D plots were greatly superior to those from the untreated check plots. This was also true of the DNBP plots except at the late stage of treatment, and of the plots that had received 1/8 pound of the ester form of 2,4-D. However, 1/2 pound of the ester had sufficiently damaged the stand to severely reduce the yields. The same was true of the TCA treatments, but primarily because the turnips were not killed, rather than because of injury to the alfalfa stand. Clover was killed by TCA. There was found to be little difference between the amine forms of MCP and 2,4-D.

In 1954 the results were very similar and there was again found to be little difference between the amine forms of 2, 4-D and MCP. However, any rate over 1/8 pound per acre injured the legume stands. The canopy at the last stage greatly decreased the legume kill at all rates used but when such a canopy was formed the oat yields were reduced. 3, 4-D was found to be considerably less toxic to the legumes than 2, 4-D or MCP. One-eighth pound of the ester of 2, 4-D caused moderate damage to the legumes at all stages, and higher rates caused more severe damage. The legumes were more tolerant of DNBP than any other herbicide.

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THE EFFECT OF POST-EMERGENCE 2, 4-D SPRAYS ON GROWTH AND DEVELOPMENT OF SOYBEANS

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Weeds have been a problem in soybeans ever since they became a major grain crop. In addition to causing yield reductions, weeds in soybeans cause other serious losses. There is a loss of grain in the field because the soybean seed is carried through the combine with weed residues. Weeds cause an extra wear and tear on combines. Dockage from too many weed seeds is quite common.

The most effective weed control measure in soybeans is cultivation. Planting soybeans in rows so that they could be cultivated was a major improvement.

Chemical weed control in soybeans has not progressed as rapidly as it has in grass crops because of the sensitivity of this crop to the present day chemicals.

Pre-emergence weed control, although promising, has not been reliable enough and has been too expensive, to be accepted by farmers as a standard practice.

In the past, soybeans have been classified as being sensitive to 2, 4-D. This classification has risen partly from the fact that soybeans show drift symptoms very easily. However, in many drift injury cases in Illinois, the yield of soybeans has not been reduced by drift.

In 1952 it was decided to study the effects of 2, 4-D on soybeans a little bit further. Rates of 1/16, 1/8, 1/4, and 1/2 pound of 2, 4-D acid in the amine form were applied to weed-free soybeans at 4 different growth stages. These stages were:

(1) soybeans 3-5 inches tall
(2) soybeans 7-9 inches tall
(3) soybeans 18-20 inches tall
(4) soybeans 32-36 inches tall

The design of the experiment was a randomized block design with 4 replications. Results of the 1952 test were so successful that the experiment was repeated in 1953 and 1954.

2, 4-D induced the following effects on the soybean plants:

1. It delayed maturity slightly.
2. It caused some reduction in height, but only noticeably so at the 1/4 and 1/2-lb. rate.
3. Lodging was severe at the 1/4 and 1/2-lb. rate at the last two dates of treatment.
4. The stand of soybeans was reduced slightly at the 1/2-lb. rate of application.

The yield data over the 3-year period indicates that the 1/16-lb. rate did not affect soybean yields at any treatment date, the 1/8-lb. rate reduced yields only at the last treatment date, the 1/4-lb. rate reduced yields slightly at the 1st treatment date, and more severely as the treatment dates progressed and the 1/2-lb. rate reduced yields at all treatment dates.

The 1/8-lb. rate, although light, will control some of the more important annual broadleaf weeds in soybeans if they are treated when small.

The following species can be eliminated with 1/8 lb. 2, 4-D:

Pigweed	- Amaranthus spp.
Annual morning glory	- Ipomoea purpurea
Cocklebur	- Xanthium spp.
Ragweed	- Ambrosia trifida

The following species are usually controlled and sometimes eliminated with 1/8 lb. of 2, 4-D:

Jimpson weed	- Datura stramonium
Velvet leaf	- Abutilon theophrasti
Smartweed	- Polygonium spp.

The reason for the tolerance in soybeans to these light rates of 2, 4-D seems to be due to the presence of pubescence on the leaves and stems of the soybean plant. Leaves of soybeans were shaved with an electric razor and the plants with pubescence removed showed much more response to 2, 4-D than did the normal plants.

Under the conditions imposed on this experiment, the following conclusions seem justified:

1. Soybeans have a considerable tolerance to 2, 4-D acid in the amine form. This tolerance is greatest when the soybeans are small and becomes progressively less as the beans grow toward maturity.

2. 1/8 lb. of 2, 4-D amine could be used on small soybeans for weed control without affecting soybean yields.

3. The tolerance of soybeans to 2, 4-D seems to be due to the fact that they are densely pubescent, which prevents much of the 2, 4-D from coming in contact with the soybean plant.

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THE USE OF DINITROS ON CORN

R. D. Ilnicki and C. J. Willard 1/

(Abstract)

Since 2, 4-D is often uncertain pre-emergence and does not control grasses post-emergence there has been a continual search for more effective chemicals for the early control of weeds in corn. One of the more promising materials is the alkanol amine salts of DNBP, sold commercially as "Premerge" or "Sinox PE".

Meggitt and Willard in 1949 obtained good results from DNBP as an emergence spray on corn.

In 1953, DNBP was applied 3 days after planting and 7 days after planting (coleoptile visible) at 5, 7, and 10 pounds per acre, and at 11 days after planting (2-3 leaves) at 1, 2, 3, 5, and 7 pounds per acre. The most effective control was obtained at coleoptile stage at the 5-pound rate. Effective weed control resulted from the early pre-emergence applications but DNBP evaporates easily, rates of 7 to 10 pounds are usually necessary if some residual effect is obtained at emergence. Young seedlings were burned by post-emergence sprays but this was not reflected in yield reductions.

In 1954, "Premerge" was applied in both 10- and 40-gallon per acre spray volume at various rates and dates as an overall and as a directed spray.

Corn was not sprayed at the 2- to 3-leaf stage in 1954, but applications at this stage in 1953 gave weed control similar to that at the 4-5 leaf stage this year, without yield reduction, even at the 7-pound rate.

These conclusions may be drawn from our data and observations:

1. Early pre-emergence applications of dinitro were not as effective as delayed pre-emergence or early post-emergence applications. High rates applied shortly after planting are effective but the same control may be obtained with lower rates when the weeds are emerging.

2. There was no difference in weed control between the 40 gal/A and 10 gal/A volumes; however, the data suggest that the concentrated sprays were more injurious to the corn at coleoptile stage than low volume sprays. Corn was not visibly damaged by any rate or spray volume at this time.

3. Although all rates produced leaf burning at the 4-5 leaf stage, this was rapidly outgrown. The weed control was less satisfactory at this time than at the coleoptile stage but there were no differences in yield.

4. Overall sprays were more injurious than the directed sprays. Severe leaf burn and stunting resulted from sprays, especially with the 10 gal/A volume. Apparently, directed sprays can be safely used in late post-emergence applications.

5. As with 2, 4-D most of the broadleaf weeds can be controlled by post-emergence applications. Post-emergence applications are effective for grass control, but their effectiveness decreases as the grasses become better established.

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THE EFFECT OF SOME CHEMICAL WEED CONTROL TREATMENTS ON THE CULTIVATION REQUIREMENTS OF CORN

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Sometimes when we try to understand the variable results we get from certain chemical treatments, we feel that we know very little about them; but our knowledge of the performance of different combinations of chemical and mechanical weed control measures is even more limited. Many of the objectives of research with herbicides are not concerned with their relation to mechanical corn cultivation. I am not picking at the objectives of weed control research workers--it is more efficient to study these things a step at a time. But the farmer--the corn grower--doesn't just spray weeds. He produces corn. He must decide how much spraying to do and how much cultivating to do. In Missouri, we advise him to use herbicides only when he has certain weed problems which cannot be handled with cultivating machinery: pre-emergence, where the problem is an almost-every-year occurrence; and post-emergence, when unusual conditions cause a problem. We do not know how chemical treatments influence the subsequent need for cultivation. If it is possible to omit one or more cultivations when chemical weed control measures are used, a considerable saving in weed control costs might result. We need to know when we can reduce the number of cultivations and when we can not. We need to know how the choice of chemicals, weather, soil, and weed conditions affect the problem.

We have scratched the surface of this problem with an experiment conducted at one location in 1953 and two locations in 1954. Four chemical treatments were applied as main plots. These were:

1. No chemical
2. 2 lb 2, 4-D ester pre-emergence
3. 1/2 lb 2, 4-D amine post-emergence
4. 3 lb DNBP amine post-emergence

Each main plot was divided into three sub-plots with three cultivation treatments:

1. No cultivation
2. Cultivated once
3. Cultivated twice

The first cultivation, on the plots cultivated twice, was made somewhat later than normal in commercial corn production where three cultivations is the usual practice. The plots receiving one cultivation were cultivated at the time of the last cultivation of those plots receiving two cultivations. Sub-plots were 3 hills x 12 hills with 10 hills of the middle row harvested for yield. Weed yields are oven-dried top growth from two to eight 20 in. x 40 in. quadrats per sub-plot. Weeds were harvested just prior to harvesting the corn.

Table 1. shows the weed yields resulting from the different combinations of chemical and cultivation treatments.

Table 1. Influence of chemical treatment and number of cultivations on the yield of weeds (cwt./A.).

Chemical treatment	Number of Cultivations 2 (cwt.)	1 (cwt.)	0 (cwt.)
None	7	14	19
2# 2,4-D Pre	3	6	9
1/2# 2,4-D Post	3	5	14
3# DNBP Post	4	6	10

The chemical treatments are listed in the column on the left. The other column headings indicate the number of cultivations within each chemical treatment--2, 1, and no cultivation. The figures in the table are the hundredweight of oven dry weeds per acre. With two cultivations, no chemical treatment resulted in 700 pounds of weeds per acre; 2 pounds 2,4-D ester pre-emergence, 300 pounds; 1/2 pound of 2,4-D amine post-emergence, 300 pounds; and 3 pounds of DNBP post-emergence, 400 pounds. With one cultivation, no chemical treatment resulted in 1400 pounds of weeds per acre; 2 pounds 2,4-D ester pre-emergence, 600 pounds; 1/2 pound 2,4-D amine post-emergence, 500 pounds; and 3 pounds DNBP amine post-emergence, 600 pounds. Plots receiving no cultivation and no chemical treatment contained 1900 pounds of weeds per acre; 2,4-D pre-emergence, 900 pounds; 2,4-D post-emergence, 1400 pounds; and DNBP post-emergence, 1000 pounds. There was little difference between the three chemical treatments on cultivated plots. 2 lb./A. of 2,4-D ester applied pre-emergence and 3 lb./A. DNBP amine applied post-emergence appeared superior to 1/2 lb./A. 2,4-D amine post-emergence on uncultivated plots. The proportion of weedy grasses to broad-leaved weeds was about the same in the case of the two post-emergence treatments--this was about 3 lb. grasses: 1 lb. broad-leaved weeds--but the pre-emergence treatment gave a ratio of about 1:1.

It can be seen in Table 1 that a chemical treatment was fully equal or superior to a cultivation. A chemical treatment without any cultivation was equal or superior to one cultivation and a chemical treatment plus one cultivation was slightly superior to two cultivations with no chemical treatment. Two cultivations without chemical treatment gave fair weed control. When combined with one of the chemical treatments, weed control was good.

Table 2 shows the corn yields obtained with these chemical and mechanical weed control measures.

Table 2. Influence of chemical treatment and numbers of cultivations on yield of corn (bu./A.).

Chemical treatment	Number of Cultivations 2 (bu.)	1 (bu.)	0 (bu.)
None	33	22	16
2# 2,4-D Pre	35	31	19
1/2# 2,4-D Post	32	28	19
3# DNBP Post	36	31	24

The chemical treatments are listed in the column on the left. The other column headings indicate the number of cultivations within each chemical treatment--2, 1, and no cultivation. The figures in the table are the bushels of 15 1/2 percent-moisture corn per acre. We have had severe droughts in Missouri in both years--1953 and 1954--so the yields are quite low.

Little advantage is shown for chemical treatments when two cultivations were made. The chemical treatments gave considerably higher corn yields than the check with only one cultivation and with no cultivation. The relatively good showing of the post-emergence DNBP treatment is in spite of later applications than are usually considered best. The corn was in the 5- to 8-leaf stage when post-emergence treatments were made. In some cases, but not always, the corn was injured by DNBP, but this did not appear to reduce the yield.

Within every chemical treatment, increased numbers of cultivations gave increased corn yields. Table 1 showed that any of the chemical treatments were equivalent to one cultivation for weed control. The corn yields did not show quite this great a benefit from the chemical treatments (except for one case--DNBP with no cultivation yielded 24 bu./A. while one cultivation with no chemical yielded 22 Bu./A.). However, in corn yields the benefits of chemical treatments were almost equal to an extra cultivation.

Summary

1. In terms of amount of weed growth at the end of the season there was little difference between the three chemical treatments tested--2 lb. 2,4-D ester pre-emergence, 1/2 lb. 2,4-D amine post-emergence, or 3 lb. DNBP amine post-emergence. However, the ratios of weedy grasses to broad-leaved weeds were different.

2. Application of DNBP at the 5- to 8-leaf stage of corn sometimes damaged the corn but did not appear to materially reduce the yield.

3. In these tests, a chemical treatment was equal to one cultivation for weed control and was almost equal to one cultivation in increasing the corn yield.

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CONTROL OF DEEP-ROOTED PERENNIAL WEEDS WITH 2,4-D-BORON COMPLEXES AND OTHER SOIL STERILIZING CHEMICALS 1/

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One of the most important factors in a program designed to prevent the spread of deep-rooted perennial weeds is the control of small areas of the weed. Several methods may be used to control these patches, but in many regions soil sterilizing chemicals have proved highly satisfactory on small areas of such weeds as field bindweed and bur ragweed. 2,4-D has been satisfactory in some areas, but in many regions this chemical has not been so satisfactory as the soil sterilant materials.

According to information from the Noxious Weed Division of the Kansas State Board of Agriculture, the use of soil sterilants in Kansas (primarily sodium chlorate and boron materials) has increased steadily since 2, 4-D became available. Thus, it is felt that these chemicals have a place in the control of many perennial weeds.

The mode of action of sodium chlorate has been studied many years. Experiments with it conducted at the Fort Hays Branch Experiment Station, Hays, Kans., since 1935 have shown it to be highly satisfactory for controlling small areas of bindweed where using it does not constitute a serious fire hazard. For areas on which sodium chlorate cannot be safely applied various boron compounds have been used. In recent years several other soil sterilants have become available. Among these materials are CMU, phenyldimethyl urea and mixtures of boron and sodium chlorate. Applications of high rates of 2, 4-D (20 to 80 or more pounds 2, 4. D acid per acre) also have been tested. In 1953 some new materials composed of mixtures of 2, 4-D and boron compounds were available for testing.

The 2, 4-D boron complexes tested were formulated as spray powders and as granular materials. In general the spray powders dissolved readily in water although slight difficulty was experienced in some instances in getting all of the material into true solution. The granular material was applied with a small fertilizer spreader similar to those commonly used to apply soil sterilants such as sodium chlorate. Both the spray powder and the granular material were judged satisfactory for field application. In the tests, results with the two materials were similar, so the method of application appears to be the deciding factor in selecting which material to use. The spray powder required a rather high volume of water per acre, but if applied only on a small patch basis, perhaps the water requirement would not be prohibitive. Both the spray powder and the granular material were applied at 4 and 6 pounds per square rod.

In discussing the results of some of the newer soil sterilizing materials it is necessary to outline briefly the effects which can be expected from such materials as sodium chlorate and unrefined boron products which have been available for many years.

According to results from 16 years of research work at the Fort Hays Branch Station, one application of 4 to 6 pounds per square rod of sodium chlorate will reduce the stand of field bindweed more than 90 percent. Some re-treatment usually is necessary to eradicate bindweed completely. Similar reductions in bindweed stands have been obtained with 10 to 12 pounds of boron trioxide (B_2O_3) equivalent per square rod applied as a boron material of relatively low solubility. Weed control with both sodium chlorate and the boron compounds is greatly affected by climatic conditions following the application. In western Kansas sodium chlorate has, however, given more consistent bindweed control than have the boron materials.

It is difficult to illustrate graphically the results obtained from treatments with soil sterilizing chemicals. Periodic plant counts on the plots treated with the various materials have been made throughout the period following treatment. These plant counts, however, do not reflect the true condition of the treated areas. The size and vigor of the remaining plants is equally as important as the total number of surviving plants.

Sodium chlorate, several boron compounds, and CMU were applied to field bindweed in May 1952. Of these chemicals, sodium chlorate at 6 pounds per square rod gave the greatest reduction in bindweed stand and vigor. CMU at 40 and 80 pounds per acre was moderately effective but not so satisfactory as the sodium chlorate. CMU at 120 pounds per acre gave virtually complete eradication of bindweed. Most of the boron compounds applied in the spring of 1952 did not give satisfactory bindweed control.

In 1953 sodium chlorate, CMU, phenyldimethyl urea, several boron compounds, borate-sodium chlorate mixtures and 2, 4-D-boron complexes were applied to bindweed. CMU at 60 and 80 pounds per acre, phenyldimethyl urea at 80 pounds per acre, and concentrated Borascu at 16 pounds per square rod were the most effective chemicals tested. Eighteen months after treatment sodium chlorate at 6 pounds per square rod was nearly as effective as the above materials.

Plant counts taken in September 1954 showed that plots treated with concentrated Borascu had only a few growing plants. Those treated with sodium chlorate had a rather large number, but the difference in size and vigor of the plants would offset the difference in actual plant numbers. Complexes of 2, 4-D and boron gave a quick top-kill of the bindweed and excellent season-long control. However, there was considerable re-growth on these plots in 1954.

The 2, 4-D boron formulations applied in the spring of 1953 were later replaced by new materials. These newer formulations were first applied in October 1953 along with the other chemicals applied in the spring of 1953. One week after treatment approximately 12 inches of snow covered the plot area. This moisture undoubtedly contributed to the action of several of the chemicals. Early in the 1954 growing season plots treated in the fall of 1953 showed excellent bindweed control as a result of nearly all of the treatments.

In the fall of 1954 a number of changes had taken place. During the 1954 growing season plots treated with sodium chlorate showed some bindweed re-growth but by November 1, 1954, many of the plants had perished. CMU and phenyldimethyl urea maintained excellent bindweed control throughout the 1954 growing season and the plots were virtually free of bindweed at the end of the 1954 season. The plots treated with 2, 4-D-boron were free of bindweed for only a few weeks during the early part of the growing season. While the number of plants on the plots at the end of the season was not particularly high, those present appeared to be normal in all respects. This indicated that the period of chemical action was of rather short duration. Eighty pounds of 2, 4-D per acre applied in the fall of 1953 gave a similar degree of bindweed control. Most of the plots treated with other boron materials in October 1953 were partially re-infested with bindweed at the end of the 1954 growing season.

Additional applications were made in May 1954. It is recognized that this experiment has not progressed far enough to draw definite conclusions, but preliminary observations may be of interest. Application of 2, 4-D at 20, 40, and 80 pounds per acre resulted in quick top-kills of the bindweed plants but regrowth appeared in approximately six weeks. At the end of the 1954 season it was impossible to tell by visual inspection the plots treated with 2, 4-D and the check areas. The 2, 4-D-boron complexes also resulted in top-kills and prevented regrowth for a longer period than the 2, 4-D alone. At the close of the 1954 season these plots showed con-

siderable reduction in the number of bindweed plants but plants remaining appeared to be growing normally. Plots treated with sodium chlorate, CMU, and phenyldimethyl urea were quite free of bindweed by November 1, 1954. In the period from September 15 to November 1, 1954 a number of plants present, particularly on the sodium chlorate treated plots, died. Thus results from sodium chlorate treatments appeared more satisfactory as the season progressed.

Experiments similar to those described for bindweed control have been conducted to determine the effectiveness of these soil sterilizing chemicals to control bur ragweed. The experimental area was located in a region that suffered an extreme drouth throughout the time the work was in progress. The results should be interpreted in light of these adverse climatic conditions.

Sodium chlorate at 4 pounds per square rod resulted in excellent control of bur ragweed. Soluble boron and boron-sodium chlorate mixtures have also proved effective in controlling bur ragweed. CMU at 40 and 80 pounds per acre was not satisfactory under conditions of the test. Complexes of 2, 4-D and boron were applied to bur ragweed in May 1953. In the fall of 1954 control on these plots was nearly equal to control with 4 pounds of sodium chlorate per square rod.

Summary

Sodium chlorate, several boron compounds, borate-sodium chlorate mixtures, CMU, phenyldimethyl urea, 2, 4-D-boron complexes, and 2, 4-D were tested to determine their effectiveness in controlling field bindweed and bur ragweed.

The applications were made in 1952, 1953, and 1954. None of the treatments was entirely satisfactory at all times of application. Sodium chlorate gave the most consistent reduction in stand of both weeds in nearly all cases. In most of the experiments CMU was rather slow in its action but when observations were made one year after application, 60 to 80 pounds per acre had given satisfactory bindweed control. Phenyldimethyl urea gave results similar to those obtained with CMU. Boron compounds gave erratic results, but applications of concentrated Borascu made in May 1953 resulted in excellent bindweed control. At rates of 20, 40, and 80 pounds per acre 2, 4-D did not give satisfactory bindweed control when applied in the spring of 1954. Eighty pounds 2, 4-D per acre applied in October 1953 gave considerable reduction in bindweed growth. Complexes of 2, 4-D and boron resulted in quick top-kills of bindweed plants and season-long control when applied in the spring of the year of 1953. Re-infestation took place in 1954 on those plots treated May 1953 as well as those treated in October 1953. Applications made in May 1954 failed to prevent bindweed regrowth during the entire 1954 season.

Although the results with 2, 4-D-boron complexes have not been entirely satisfactory in western Kansas these new materials appear to be sufficiently effective as herbicides to warrant further testing. Studies should be made concerning the effect of climatic factors and the effect of time and rate of applications on the action of the materials. Unpublished data received through correspondence indicated that in some locations the chemicals have been highly effective in controlling field bindweed, Canada thistle and other perennial weeds.

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THE EFFECT OF VARIOUS FORMULATIONS OF MCP AND 2, 4-D ON WEEDS IN GRAIN CROPS

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The role of MCP in the weed control program for small grains in Western Canada has never been clearly established, notwithstanding that plot and field trials with various formulations of MCP were initiated as early as 1949. The failure of MCP to control Russian thistle, Salsola kali, one of the major weeds of the spring wheat growing area, caused interest in this herbicide to drop off sharply. The better than average growing conditions in each of the past three or four years have been largely responsible for numerous instances of severe crop damage to oats and flax from the use of 2, 4-D, particularly the ester formulations. This situation, coupled with the observation that some weed species, notably hemp nettle, Galeopsis tetrahit, were controlled more effectively with MCP than 2, 4-D, have markedly stimulated interest in the former herbicide. Further interest was created by the findings of Coupland, Olson, Brown and others published in the last three NCWCC Research Reports, since these indicated that MCP, while often giving poorer weed kills, usually resulted in the highest yields of grain. Since the cost of MCP is roughly three times the cost of 2, 4-D per ounce of acid in Canada, it was felt that a more critical assessment of the merits of MCP was needed. Therefore a co-operative project, to be conducted on as many Experimental Stations as possible, was designed to meet this need.

The chief objectives of this co-operative project were to find answers to the following questions:

1. Are separate recommendations justified with respect to the stage of growth at which oats and flax should be sprayed with MCP.
2. Should MCP be recommended in preference to 2, 4-D for weed control in small grain because of its reportedly greater crop safety potential.
3. Determine the reaction of as many weed species as possible to both MCP and 2, 4-D formulations.

The project was divided into the following four major parts: Part 1 - was designed to compare the effect of the ester and amine formulations of MCP and 2, 4-D on oats when applied at twenty different growth stages, under weed-free conditions. This work was laid down at only three Stations because similar work had already been conducted at several Stations in 1953. Part 2 - was designed to compare the effect of MCP and 2, 4-D

formulations on annual and winter annual weeds growing in a grain crop. This part of the project was laid down at seven stations in Western Canada. Part 3 - was included to compare the effects of these herbicides on perennial weeds both on land in crop and not in crop. This trial was initiated on four Experimental Stations with Canada thistle Cirsuim arvense and perennial sow thistle Sonchus arvensis the weed species of major concern.

Part 4 - was designed to test the effect of the volume of water used for the spraying of legumes. This part of the project has an indirect bearing on the subject of this paper in that the findings might be of value in making recommendations for treating crops undersown with legumes. This trial was carried out on alfalfa at one Station and on canning peas at another. Unfortunately an extremely wet and abnormally cool growing season coupled with frost damage interfered with the work on a number of the stations. Consequently, only a very limited amount of data are available for discussion at this time.

The effect of spraying an ester of 2, 4-D and MCP each at 1/4 lb/A and the amine salts of these two compounds each at 1/2 lb/A on the yield of weed-free Rocket flax are shown in Table 1. Sprayings were made at twenty growth stages (3 day intervals) at Brandon and at five growth stages at Regina, Sask. The data presented do not suggest any radical changes in the recommendations for the use of these herbicides in flax as laid down in 1953, i.e. flax should be sprayed as soon as there has been sufficient weed emergence to be practical. It was significant to note, however, that the MCP formulations did not depress the yields to quite the same extent at the very early treatments viz: pre-emergence to 1 1/2 inches in height. It might bear mentioning at this point that treatment before the flax plants were 2 inches tall was not recommended in Western Canada in 1953. A further significant observation at Brandon was that with the 2, 4-D ester severe yield reduction occurred as soon as the flax had reached the mid-bud stage; with the 2, 4-D amine this did not occur until late bud stage and was not as severe at any time; while with the MCP formulations severe injury did not take place until the late bloom stage. On the basis of the 1954 yields presented in Table 1 there would not appear to be any justification for recommending the MCP rather than the 2, 4-D formulations unless circumstances required that spraying be done during the bud and early flower stages or before the flax plants were 2 inches tall.

Results from the 20 dates (3 day intervals) of spraying of Exeter oats with an ester of MCP and 2, 4-D each at 1/4 lb/A and the amine of each of the compounds at 1/2 lb/A were available only from Lacombe, Alta. in 1954. Since these results were influenced to some extent by hail and then by frost the actual yields will not be presented. The greatest yield depressions in the test resulted from the use of the 2, 4-D formulations at two separate growth stages viz: 1) the time of node formation, 18 to 24 days after emergence and 2) just prior to heading, 45 to 50 days after emergence. The 2, 4-D treatments made at the time of node formation resulted in severe lodging. However, the chief reason for the reduced yields was ascribed to floret sterility and the prevention of panicle development, particularly in the later tillers. Thus, the 1954 observations generally follow previous findings with respect to the use of 2, 4-D in oats. The results with MCP were of particular interest in that the treatments made at any time from emergence until the advanced boot stage did not notably depress the yield, nor cause the lodging noted in the 2, 4-D treated plots.

Due to the widespread adverse weather conditions data with regard to the effect of MCP versus 2, 4-D for the control of annual weeds in oats were at this time only available from one of the seven stations, namely Lacombe, Alta. In this test 2, 4-D ester and amine; MCP ester, amine and sodium salt; and low volatile propylene glycol butyl ether ester were each applied at 1/4 and 1/2 lb/A in 7 gal/A of water. Sprayings were made at two dates, viz: the seedling and the early bud stage of stinkweed, the major weed species. The plot size was 10 x 20 feet and the experimental design used was a 5 x 5 Balanced Lattice having six replications. The plot area was seeded to a mixture of annual weeds in the spring prior to the seeding of Eagle oats on the plots themselves. The predominant weed species was stinkweed, Thlaspi arvense, which accounted for some 50 percent of the entire weed population. Hemp nettle, Galeopsis tetrahit, was the second major species and accounted for roughly 25 percent of the population. In order of prevalence, ball mustard, Neslia paniculata, lambs' quarters, Chenopodium album, Russian pigweed, Axyris amarantoides, chickweed, Stellaria media, and green foxtail, Setaria spp, made up the remaining 25 percent of the population. The treatments, weed densities before and after treatment, dry weight of weeds and yield of oats per acre are given in Table 2.

Before discussing weed control and yields, it would be in order to say a few words with regard to techniques. In this test three methods of assessing weed populations were attempted, namely, 1) visual estimates, 2) point sampling and 3) dry weight of weeds. Point sampling was felt to have a very marked advantage over visual estimates as to accuracy. This technique was very satisfactory for assessing the weed population at the time of spraying and these readings expressed as percent ground cover are given in the table. Difficulty arose with the weed appraisal after treatment because during the time required for the susceptible weeds to die the oats had developed to such an extent that it would have been too severely trampled by point sampling to permit accurate yield analysis. A further difficulty was encountered with hemp nettle which showed a high degree of tolerance, particularly to the 2, 4-D formulations. The MCP formulations very severely stunted the nettles but three weeks after treatment, when the last point sampling was done, none of the treated plants had died, indeed due to subsequent emergence there were more nettle plants after treatment than before. Plant counts made on the samples taken at flowering and used to determine the dry weight of the weeds present rather convincing evidence that a fair proportion of the MCP treated nettles eventually were killed. Nevertheless the method was not found to be practical with semi-tolerant weeds because it gave little or no measure of the effectiveness of chemicals which controlled but did not kill such species.

In this project each of the treatments at each date resulted in almost complete removal of the stinkweed, ball mustard, lambsquarters and Russian pigweed. Chickweed and foxtail were neither killed nor effectively controlled by any of the treatments. As shown by the plant counts and dry weights taken during the late flowering stage of the weeds the MCP treatments made at date 1, seedling stage, resulted in a large measure of control of the hemp nettle as well as the stinkweed and other weeds. The effect of this control is directly reflected by the increased yields of oats. The MCP ester at 1/4 and 1/2 lb/A and the MCP amine at 1/2 lb/A each resulted in significantly higher yields than the untreated check. The 2, 4-D ester and low volatile ester did not control the nettles and resulted in little or no increase in yield, not withstanding that a heavy infestation of stinkweed had been removed by each of these treatments. Although the oat crop was in the

full four leaf stage at the time of treatment, the preponderance of plant deformities from these ester treatments would suggest that the lower yields were due, at least in part, to herbicidal injury to the crop. The yields following treatment with the 2, 4-D amine were much higher. These yield increases can be ascribed to lighter nettle infestation and greater crop tolerance. As shown by the dry weights of weeds and yields of oats the control of hemp nettle by any of the MCP formulations was not as effective at date 2 as it was at date 1. At this later date of treatment the nettles had a longer period in which to compete with the crop. Furthermore the crop was approaching the shot blade which largely accounts for the lower yields following the 1/2 lb/A dosage of MCP. The yields in table 2 would indicate that the oats were less tolerant to the MCP ester than to either the amine or sodium salt. The 2, 4-D and low volatile ester treatments, with the exception of the amine at 1/4 lb/A very sharply decreased the oat yield despite the removal of a heavy infestation of stinkweed, ball mustard and lambsquarters.

In summing up the yields of all MCP treatments and all 2, 4-D treatments at each of the two dates it was of interest to note that the mean yield on the MCP plots was 4.3 bushels per acre higher at date 1 and 9.3 bushels per acre higher at date 2 than the mean yield on the 2, 4-D plots. The difference in cost for chemical, if MCP rather than 2, 4-D were to be used at a dosage of 6 oz/A, would be 70 cents per acre. On the basis of this trial where hemp nettle accounted for about one quarter of the initial weed infestation the use of MCP would quite obviously be preferred. Also emphasized in this trial was the importance of early treatment if maximum weed control and crop yields are to be attained. The hazard of serious injury to the oat crop from the use of the 2, 4-D ester and low volatile ester was pointed out.

This part of the project was conducted on stinkweed and wild buckwheat in wheat at Scott, Sask. in 1954. Each of the treatments resulted in almost complete elimination of the stinkweed when applied during the early or seedling stage. The second date of spraying was delayed until the stinkweed was in the pod stage and none of the treatments resulted in satisfactory control. None of the treatments controlled the wild buckwheat at either of the dates of treatment. The very heavy growth of wild buckwheat prevented any of the treatments from significantly affecting the yield of wheat.

Only one report with regard to MCP versus 2, 4-D for the control of perennial weeds was received. This report showed that on land not in crop the 2, 4-D formulations resulted in better top growth control than did the MCP formulations, when used at comparable rates. Final appraisal of these treatments will not be available until 1955.

The results presented by Bucholtz in 1953 indicated an increased tolerance in peas to MCP if the chemical were applied in volumes of water greater than 5 gal/A. The results obtained by Sexsmith, who sprayed an amine of each of 2, 4-D and MCP at 2, 4 and 8 oz/A at each of four different spray volumes, to Topper Canning peas in 1954, are given in Table 3. As shown in this table increased spray volume very significantly decreased the injury ratings. Since the test was run on almost weed-free plots, none of the treatments gave higher yields than the untreated check. However, increased spray volume, especially the volumes of 23 and 42 gal/A of water prevented serious yield reductions. Although this test was laid down at Swift Current on alfalfa in 1954 the results were not available.

Table 1. Effect of 2, 4-D and MCP on Rocket Flax 1954. Brandon and Regina

Date and Stage of treatment		Brandon Yield in bushels				Regina Yield in bushels			
		E4	A8	MCPE4	MCPA8	2, 4-DE4	2, 4-DA8	MCP E4	MCP A8
1. May 28	0"	12.0	11.2	11.6	12.1				
2. May 31	1/4"	10.8	10.4	13.2	12.0				
3. June 5	1"	10.5	13.2	14.2	10.4				
4. June 10	1"	13.6	15.6	12.6	12.6	20.7	14.8 **	21.3	19.1 *
5. June 14	2 1/2"	12.1	13.8	13.7	13.0				
6. June 16	3"	14.0	12.4	13.0	13.8	15.9 *‡	17.9 **	17.7 **	18.0 *
7. June 19	4"	12.8	14.2	14.0	12.0				
8. June 21	5"	12.4	11.9	12.4	13.3				
9. June 25	5 1/2"	13.9	12.4	13.4	14.9	11.4 **‡‡	9.0 **‡‡	19.6	16.4 **
10. July 2	6"	11.1	9.5	13.5	13.7				
11. July 5	9"	11.4	12.3	15.2	14.5				
12. July 7	10"	8.6	11.6	11.2	13.0				
13. July 9	12"	10.6	12.7	11.9	15.3	8.0 **‡‡	7.8 **‡‡	19.8	13.8 **‡‡
14. July 12	15"	10.5	11.4	11.2	12.4				
15. July 14	17"	8.6	10.6	11.0	12.5				
16. July 16	18"	9.4	9.8	11.3	10.5				
17. July 19	20"	7.8	8.0	10.1	10.6	6.7 **‡‡	3.7 **‡‡	11.9 **‡‡	10.5 **‡‡
18. July 21	21"	8.3	9.4	10.7	12.3				
19. July 23	22"	2.6	8.9	10.1	8.5				
20. July 26	22"	6.9	8.4	8.4	8.3				
Check				12.9				23.9	
L.S.D. at 5%				3.0 bu.				4.5 bu.	
L.S.D. at 1%				3.9 bu.				6.0 bu.	

* Significant decrease in yield, compared with check plots.
** Highly significant decrease in yield, compared with check plots.

‡ Significant decrease in yield, compared with yield from date of least injury.
‡‡ Highly significant decrease in yield, compared with yield from date of least injury.

Table 2. MCP vs 2,4-D for the Control of Annual Weeds in Oats, Lacombe, Alberta, 1954

No.	Treatment	Date	Days to Mature	Height Inches	% Ground Cover of Weeds at time of Treatment				Weed Count Taken at Flowering Stage				Yield Bu/A	Dry Weight of Weeds at Flowering lb/A
					H.N.*	S.W.‡	Others	Total	H.N.*	S.W.‡	Others	Total		
1	Check	0	119	42	13.8	19.7	9.6	43.1	63.5	164.5	82.3	310.3	35.0	886.69
2	MCPE -4	1	119	45	15.4	20.8	9.0	45.2	76.2	1.0	3.3	80.5	42.2*	173.84
3	MCPE - 8	1	120	45	12.5	17.1	9.4	39.0	19.8		2.8	22.6	43.0*	33.39
4	MCPS - 4	1	118	45	5.0	20.4	9.4	34.8	24.8	.8	10.7	36.3	38.7	45.05
5	MCPS - 8	1	119	45	9.2	19.4	7.9	36.5	18.2	1.2	7.2	26.6	38.5	30.21
6	MCPA - 4	1	117	44	5.2	14.3	10.1	29.6	17.3	.2	9.3	26.8	40.2	27.56
7	MCPA - 8	1	119	44	5.9	19.0	9.2	34.1	4.8	1.0	3.2	9.0	43.2*	5.30
8	E - 4	1	119	45	7.2	10.7	9.9	27.8	142.5	3.2	6.5	152.2	33.1	550.14
9	E - 8	1	119	45	12.2	18.6	10.3	41.1	121.2		3.8	125.0	36.9	720.80
10	A - 4	1	121	43	4.5	16.9	9.6	31.0	57.0	8.5	8.9	74.4	38.7	444.14
11	A - 8	1	118	45	4.1	14.7	8.3	27.0	35.3	.2	2.8	38.3	40.7	136.21
12	LV - 4	1	120	44	10.7	14.0	7.7	32.4	110.7	1.0	1.3	113.0	37.0	646.60
13	LV - 8	1	120	42	10.0	17.3	8.5	35.8	80.5	.2	3.7	84.4	33.1	397.50
14	MCPE - 4	2	118	44	8.3	22.5	9.3	40.1	62.2	.2	11.6	74.0	35.0	296.80
15	MCPE - 8	2	120	43	10.5	25.6	10.4	46.5	41.0		.7	41.7	33.0	149.46
16	MCPS - 4	2	118	45	6.0	14.9	8.0	28.9	27.5		6.5	34.0	40.1	59.36
17	MCPS - 8	2	120	43	12.1	25.3	9.2	46.6	91.5		2.0	93.5	38.2	292.56
18	MCPA - 4	2	119	43	4.9	14.7	9.3	28.9	18.7	.2	5.3	24.2	41.4	30.21
19	MCPA - 8	2	119	45	5.9	16.6	10.6	33.1	25.0		2.0	27.0	37.5	58.30
20	E - 4	2	119	43	12.1	25.8	10.6	48.5	126.8	.5	4.0	131.3	28.6	421.35
21	E - 8	2	121	43	3.6	23.7	10.9	38.2	23.0		1.8	24.8	22.4-	81.09
22	A - 4	2	120	43	7.1	15.3	11.1	33.5	53.5		6.0	59.5	36.0	251.75
23	A - 8	2	120	44	7.0	11.7	8.0	26.7	56.8		1.2	58.0	29.7	645.01
24	LV - 4	2			6.4	13.5	8.5	28.4	49.0		1.8	50.8	28.6	332.31
25	LV - 8	2			9.1	23.5	9.6	42.2	72.8		1.2	74.0	23.3-	465.34

* Hemp Nettle
‡ Stinkweed

MCP vs. 2, 4-D
"Spray Volume Test on Canning Peas"
Lethbridge, Alberta - 1954

Spray Volume gal/A	Chemical amine	Rate oz/A	Injury Rating[1] 0-10	Tender-ometer Reading[2]	Shelled Peas tons/A
6.30	2,4-D	0	0.0	133	1.25
		2	3.0	133	0.83
		4	8.0	121	0.28
		8	10.0	-	0.11
"	MCP	0	0.0	132	1.25
		2	0.7	124	1.19
		4	1.0	131	1.26
		8	8.7	125	0.84
12.00	2,4-D	0	0.0	147	1.31
		2	1.0	138	1.12
		4	3.7	143	0.59
		8	9.3	-	0.15
"	MCP	0	0.0	135	1.21
		2	0.0	133	1.06
		4	0.0	135	1.20
		8	4.3	133	1.10
23.16	2,4-D	0	0.0	125	1.52
		2	1.0	125	1.17
		4	1.3	136	1.03
		8	6.7	140	0.34
"	MCP	0	0.0	129	1.53
		2	0.7	130	1.36
		4	0.3	131	1.32
		8	1.3	122	1.26
42.23	2,4-D	0	0.0	125	1.42
		2	0.3	123	1.31
		4	0.7	136	1.26
		8	1.7	135	0.89
"	MCP	0	0.0	128	1.28
		2	0.0	135	1.32
		4	0.0	129	1.20
		8	0.3	128	1.07[3]
				L.S.D.	0.28

[1] Injury rating scored 10 days after treatment, 0 to 10, from no injury to serious stunting and delayed blooming.

[2] Insufficient sample for reading where no entry; analysis of data excluding 8-oz. rates showed no significance.

[3] Low yield for 8 oz. MCP at high volume application due in part to fact that plot in Rep. III in alkali area.

Note: All entries average for three replicates, test laid out as split plot with volume rate as whole plot, split to chemical, and then to rate.

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THE CONTROL OF WEEDS IN ALASKA FIELD CROPS WITH DINITRO SPRAYS 1/

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Weeds have followed man in his migrations for centuries and more recently have followed him to Alaska. This is illustrated by the very high weed populations in many fields even though they have been in cultivation less than fifteen years. Cultural practices have not succeeded in combating this problem because most of the troublesome weeds, chickweed, lambsquarters, wild buckwheat, and the mustards, are difficult to control during the peculiar, cool, wet weather after mid-summer. Also, the main field crops, such as small grains, oat-pea mixtures, and annual forages do not permit cultivation during very much of the growing season.

Herbicides have not been widely used in Alaska in spite of their obvious advantages. Several reasons may account for this situation. Plant reactions to the common herbicides often differ from those observed in the States. Thus, when labeled recommendations are used, erratic and disappointing results are often experienced. The prevalent weed species are somewhat different so that any specific herbicide commonly used on a field crop in the States may be ineffective in controlling the weeds present. Therefore, the extensively reported research must be reappraised and adapted before a sound weed control program can be developed in Alaska.

Preliminary investigations have shown that dinitro compounds effectively control weeds in many Alaskan field crops. These studies were initiated in an attempt to determine the optimum rate as well as date of application for maximum weed control and crop yields.

Experimental Results

Small Grains: Studies were made comparing several rates of dinitros in amine form on oats in 1953 and barley in 1954. Pre-emergence and post-emergence applications were made at several dates.

Briefly, the weather during June 1953, when the spray applications were made, was quite dry and around 60°F. Total precipitation amounted to 0.47 of an inch, considerably below normal. Rain did not immediately precede or follow any of the applications. Average maximum temperatures averaged 72° and minimum temperatures 47°, somewhat above normal. The weather in late May 1954 averaged about 10° colder than June 1953 and about twice as much precipitation was recorded in 1954. However, the period preceding planting in 1954 was very dry. A light rain was recorded on the second spray date in 1954.

Results of the pre-emergence trials for the small grains in 1953 and 1954 are summarized in Table 1. In 1953, dinitro was applied to oats at rates from 3 to 7 1/2 pounds per acre. The more favorable rates were applied to barley in 1954. All applications increased grain yields over the controls, 9 bushels in 1953 and 6 1/2 bushels in 1954. The 3 and 4 1/2 pound rates were significantly higher than the controls both years. No significance in yield response was noted among the dates of applications in 1953. However, in 1954 yields increased progressively as the date of application was delayed. This may have been a result of the very dry conditions at planting time and the light rain at the 6 day application. The results indicate that 3 to 4.5 pounds per acre applied several days after planting will give satisfactory weed control with no crop toxicity. Higher applications of 6 to 7.5 pounds in 1953 did not injure the oats, but were not any more effective in controlling weeds or increasing grain yields than the lower rates.

Results of the post-emergence trials with oats in 1953 and barley in 1954 are summarized in Table 2. Considerable yield reductions were noted in the post-emergence trials in 1953, particularly at the higher rates of 2 1/2 and 3 pounds per acre applied when the oats were about 6-8 inches tall. A similar reduction was noted in 1954 although it was not significant. Excellent weed control with no crop toxicity was obtained with 3/4 and 1 1/2 pounds per acre in 1953 and 1 1/2 and 2 1/4 pounds per acre in 1954.

Table 1. Average Yields in Bushels per Acre of Oats and Barley Treated With Pre-emergence Applications of Dinitro (amine)

1953 - Oats

Date of Application	Pounds of chemical per acre: 0	3.0	4.5	6.0	7.5	Avg.
Planting time	-	67.7	74.0	68.7	65.6	67.3
4 days	-	69.0	71.0	71.7	73.3	69.1
8 days	-	75.3	70.0	67.0	66.0	67.8
Avg.	60.7	70.7*	71.7*	69.1	68.3	68.0

L.S.D. - (1) between rate means: 5% - 8.5; 1% - 11.5
(2) " date " : " - 6.6; " - 8.9
C.V. = 13.0

1954 - Barley

Date of Publication	Pounds of chemical per acre: 0	3.0	4.5	6.0	Avg.
Planting time	-	50.5	50.8	48.5	49.4
6 days	-	56.3	58.7	51.2	53.7*
10 days	-	55.0	60.0	56.5	54.5**
Avg.	47.5	53.9**	56.5**	52.1*	52.5

L.S.D. - (1) between rate means: 5% - 4.2; 1% - 5.6
(2) " date " : " - 3.7; " - 4.9
C.V. = 12.0

A general comparison of pre-emergence and post-emergence applications on small grains shows that satisfactory weed control was obtained with post-emergence sprays at considerably lower rates of chemical. However, the time of application appears to be more critical in post-emergence than in pre-emergence applications. From a practical standpoint, the cost of the chemical must be resolved against consistant and satisfactory weed control with corresponding increases in yields.

Forage Legumes: Severe infestations of chickweed and lambsquarters often cause partial or complete stand losses of forage grasses and legumes which normally have a slow seedling growth. Dinitro sprays were applied in 1953 and 1954 on three legumes, alfalfa, sweetclover, and red clover seeded without a grain companion crop. Pre-emergence applications were made at rates of 3 to 7.5 pounds per acre 4 days after seeding. Post-emergence applications were made at rates of 3/4 to 3 pounds per acre when the legumes were in the 3-4 leaf stage or about 6 weeks after planting. The treatments were subsequently rated for stand reduction, crop toxicity, and weed toxicity.

Excellent weed control was obtained with all rates of dinitro applied as pre-emergence sprays. Very little crop toxicity or stand reduction was noted in any of the 3 legumes at any of the rates. However, 4.5 pounds per acre appeared to give the most satisfactory weed control as well as protection from subsequent weed infestations later in the season. In 1954, Medicago falcata was used in the tests. It has a very slow seedling vigor and as a result some weeds were able to infest the plots late in the season. With crops that are as slow to start as M. falcata, it might be advisable to increase the rate of application to 6 pounds per acre.

In contrast, the post-emergence applications gave very poor weed control with correspondingly high crop toxicities and stand reductions. This was most pronounced in sweetclover where the plants were almost completely killed even at rates of 1.5 pounds per acre. These trials show that post-emergence applications of dinitro cannot be used to selectively control weeds in establishing legumes.

A fortunate aspect of the legume and small grain trials is that the most satisfactory rate of herbicide, 4.5 pounds per acre applied as a pre-emergence spray, is the same for both field crops. This greatly facilitates the practical use of dinitros because the same rate can be used regardless if grain is grown alone, underseeded with forages, or the forages are established alone.

In spite of the promising nature of the dinitro sprays, some serious limitations are recognized. The dinitros failed to control several weed species amongst them being wild buckwheat which is becoming increasingly important, particularly when other weed competition is removed. This problem becomes even more serious when growing grain for seed. The high volumes of spray needed for effective results increase the cost and time of application considerably. The herbicide is relatively expensive and not the most desirable chemical with which to work.

Summary

Several rates of dinitro in amine form were applied to small grains as pre-and post-emergence sprays at several dates. Pre-emergence applications of 4.5 pounds per acre gave the largest grain yield increases indicating satisfactory weed control with little crop toxicity. Considerable crop toxicity was noted in the post-emergence application, particularly at the higher rates applied when the grain was 6-8 inches. Time of application appeared to be more critical in the post-emergence than in pre-emergence sprays.

Excellent weed control was obtained with pre-emergence applications of dinitro to alfalfa, red clover, and sweetclover. However, post-emergence applications cannot be used to selectively control weeds in establishing legumes.

1/ Contribution of the Agronomy Dept., Alaska Agricultural Experiment Station, Palmer, Alaska

2/ Alaska Agricultural Experiment Station, Palmer, Alaska

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Table 2. Average Yields in Bushels per Acre of Oats and Barley Treated With Post-emergence Applications of Dinitro (amine)

1953 - Oats

Date of Application	Pounds of chemical per acre 0	0.75	1.5	2.25	3.00	Avg.
12 days (emerging)	-	70.3	73.0	75.0	69.0	69.6
19 days (3-in.)	-	74.3	74.0	65.0	62.3	67.3
26 days (6-8-in.)	-	65.3	58.0	54.3	54.0	58.5**
Avg.	60.7	70.0*	68.3*	64.8	61.8	65.1

L.S.D. - (1) between rate means: 5% - 7.5; 1% - 9.9
(2) " date " : " - 5.7; " - 7.7
C.V. = 11.7

1954 - Barley

Date of Application	Pounds of chemical per acre 0	1.5	2.25	Avg.
20 days (2-4-in.)	-	61.5	57.5	56.6
30 days (6-8-in.)	-	53.8	56.5	53.9
Avg.	50.9	57.6**	57.0**	55.2

L.S.D. - (1) between rate means: 5% - 3.9; 1% - 5.4
(2) " date " : " - 3.2; " - 4.4
C.V. = 6.6

COMPARING GROUND AND AIR APPLICATIONS OF 2, 4-D ON WHEAT

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The problem arose as a result of reported injury to wheat from being sprayed with 2, 4-D by commercial airplane sprayers and reported injury from certain formulations of 2, 4-D. Since very little research data concerning such applications were available it seemed that present recommendations should be reviewed in order to determine the cause of such damage and perhaps the need for separate recommendations for aerial spraying.

The purpose of this study was to compare air to ground as means of application, oil to water as carriers, different formulations of 2, 4-D, different rates of 2, 4-D and different volumes of carrier.

A preliminary experiment was run at Strool, South Dakota during the summer of 1952. This work indicated that there might be some differences between air and ground application and showed the need for further study on the problem.

In order to study the individual comparisons closer, several experiments were designed and each comparison analyzed separately. The design of each will be discussed later as results are presented.

Methods and Results

These experiments were run at two locations (Strool and Huron, South Dakota) for two years. Air plots were 50 feet wide and 60 feet long with the swath width 36 feet wide at Strool and 42 feet wide at Huron. However, due to the fact, that it would be difficult to spray a plot that size by airplane all six reps were sprayed in one pass with no randomization. The groundplots were 20 feet wide and 60 feet long, were sprayed with a field type ground sprayer with a boom 1 rod wide and were randomized among the air plots. Although this left restricted randomization, it was felt that the plot size that could be used in this manner, as compared to the size of plot that an airplane could spray, more than compensated for the restricted randomization.

In the comparison of different formulations a randomized block design with sextuplicate plots was used. Table 1 shows the treatments used and the mean wheat yields for the six replications.

Table 1. Mean Wheat Yields Using Different Formulations of 2, 4-D at 1/3 lb/A

	Strool		Huron	
	53	54	53	54
Butyl ester (emulsifiable)	--	7.2	--	8.3
Butyl ester (non-emulsifiable)	10.9*	5.1	5.5	7.9
Isopropyl-butyl ester	--	7.3	--	7.9
Ethyl ester	11.3*	--	5.1	--
Untreated	17.5	7.6	5.5	8.5

*Significantly different from untreated at .05 level

In 1953, at Strool, both butyl ester and ethyl ester of 2, 4-D gave significantly lower yields than the untreated check, however, at Huron no significant differences were noted, nor were there any significant differences in 1954 at either Strool or Huron. Thus, indicating that the type of formulation had little or no effect on wheat yields.

A randomized block design with sextuplicate plots was used in the comparison of carriers. Three carriers, water, heater oil (No. 1 Diesel fuel) and furnace oil (No. 2 Diesel fuel) were compared when applied alone and with 2, 4-D at 1/3 lb acid equivalent per acre. Table II shows the treatments used and the mean wheat yield for six replications.

Table II. Mean Wheat Yields When Three Different Carriers Were Applied With and Without 1/3# 2, 4-D/A

	Strool		Huron	
	53	54	53	54
Heater oil only	15.9	10.4**	6.5	8.6
Heater Oil + 2, 4-D	8.6*	8.5**	5.7	8.9
Furnace oil only		12.3*	5.3	10.1
Furnace oil + 2, 4-D	6.5*	7.6**	5.3	8.2
Water only	16.1	11.8*		9.3
Water + 2, 4-D	13.6	7.1**	5.3	7.6
Untreated	17.5	16.4	5.5	8.5

* Significantly different from untreated at .05 level
**Significantly different from untreated at .01 level

At Strool in 1953, both heater oil and furnace oil with 2, 4-D gave significantly lower yields than the untreated. In 1954 applications of heater oil only, heater oil + 2, 4-D, furnace oil + 2, 4-D and water + 2, 4-D all gave highly significant reductions in yield, while furnace oil alone and water alone showed significantly lower yields than the untreated. However, in 1954 at Strool the untreated check was in a more favorable position and possibly reduction in yields would not be quite as significant had the untreated plot been located on soil with the same fertility.

At Huron neither year showed any significant differences in wheat yields.

In comparing volumes of carrier a split plot design was used with volumes as main plots and treatments as subplot. Sextuplicate plots were treated with a butyl ester of 2, 4-D at 1/3 lb acid equivalent per acre using water and oil as carriers. Carriers of 1/2, 1 and 2 gal/A of oil and water were applied by air, and carriers of 2, 5 and 10 gal/A of water and 2 and 5 gal/A of oil by ground. Spray retention studies were also carried out in this phase of the experiment by incorporating blue dye into the spray solution and using the method devised by Woofter at C amp Deitrich. At the time of treatment, 3 sq. yd. samples were cut from each of 3 replicates. Each of the three replicates was then washed and spray retention calculated from a curve plotted from colorimeter readings of known concentrations. A piece of adding machine tape was placed across the plot sprayed to determine the spray pattern and its uniformity.

Tables III and IV show comparison of mean wheat yields among volumes and comparison of mean wheat yields within volumes respectively.

Table III. Mean Wheat Yields When Varying Volumes Of Carrier Were Used in Applying 1/3 lb 2, 4-D/A

	Strool		Huron	
	53	54	53	54
1/2 gal/A	6.7	9.1	6.0	8.9
1 gal/A	12.7*	6.1*	5.7	8.3
2 gal/A	8.6**	5.7	5.0	7.6
5 gal/A	10.3	5.7	5.0	6.5
10 gal/A	12.3	6.0	5.3	5.8

* Significantly different from 1/2 gal/A at .05 level
** Significantly different from 5 gal/A at .05 level

At Strool in 1953 the 1 gal/A volume gave significantly higher yields than the 1/2 gal/A volume but in 1954 the situation was just reversed; also, in 1953 the 2 gal/A volume was significantly lower than the 5 gal volume. Neither year showed any significant differences at Huron, indicating that volumes of carrier had little effect on wheat yields.

Table IV. Mean Wheat Yields When Comparing Carriers Within Volumes When 1/3 lb 2, 4-D/A Was Applied

	Strool		Huron	
	53	54	53	54
1/2 gal oil (air)	6.6	10.4*x	5.3	9.3
1/2 gal water (air)	7.3	7.8	6.7	8.5
Untreated	8.0	6.7	6.2	8.3
1 gal oil (air)	8.6*	6.6	5.7	9.5
1 gal water (air)	13.6	5.6	5.3	7.1
Untreated	17.5	6.7	5.5	8.3
2 gal oil (air)	9.2*	5.5	4.7	6.8
2 gal water (air)	8.3*	5.6	5.6	6.9
2 gal oil (ground)	8.3*	4.4	4.2	7.2
2 gal water (ground)	7.8*	6.4	5.0	8.6
Untreated	11.4	5.0	5.4	8.2
5 gal oil (ground)	10.0*	5.8	4.3	6.6
5 gal water (ground)	9.1	5.5	4.9	6.3
Untreated	5.2	6.3	3.9	5.8
10 gal water (ground)	13.7	6.0	4.7	7.1
Untreated	17.5	6.3	5.5	5.8

* Significantly different from untreated at .05 level
x Significantly different from 1/2 gal water (air) at .05 level

In 1954, at Strool the 1/2 gal oil gave a significantly higher yield than either the 1/2 gal water or the untreated plot. At Huron no significant differences were noted in either 1953 or 1954. At Strool in 1953 the applications of 1 gal oil (air), 2 gal oil and water (air and ground) and the 5 gal oil (ground) were significantly lower than the untreated check. Some significant differences were observed at Strool in 1953 and one in 1954 however, since these occurred at only one place it is assumed that carriers had little effect on wheat yields.

In comparing different rates of 2, 4-D randomized block design was used. Sextuplicate plots were treated with a butyl ester of 2, 4-D at 1/8, 1/4, 1/3, 1/2 and 3/4 lb acid equivalent per acre using 1 gal oil/A for air and 10 gal water/A for ground as carriers. Table V shows the treatments made and mean wheat yields for the six replications.

Table V. Mean Wheat Yields When 2, 4-D Was Applied At Varying Rates

	Strool		Huron	
	53	54	53	54
1/8# Air	14.6	6.2*	7.2	7.3
Ground	17.6	6.8*	5.2	7.7
1/4# Air	17.5	6.2*	5.9	8.9
Ground	12.9	6.3*	5.8	7.4
1/3# Air	15.8	7.8*	8.4	7.4
Ground	14.4	5.0*	6.3	8.4
1/2# Air	15.6	5.8	6.7	7.0
Ground	12.8	5.7	5.2	8.3
3/4# Air	13.9	4.3*	5.5	6.9
Ground	10.7	4.6*	4.8*	7.1
Untreated	12.8	5.6	7.3	9.3

*Significantly different from untreated at .05 level

The 3/4 lb/A of 2, 4-D applied by ground and air gave significantly lower wheat yields than the untreated check at Strool in 1954 and by ground only at Huron in 1953. 1/3 lb/A applied by ground also showed significantly lower yields at Strool in 1954. However, at Strool in 1954 both air and ground applications of 1/8 and 1/4 lb/A gave significantly higher yields than the untreated as did the 1/3 lb/A by air. These results indicate that rates of 1/2 lb 2, 4-D acid equivalent/A or less gave no reduction in yield, whereas plots treated with 3/4 lb/A gave significantly lower yields.

Aerial Observation

This phase of the investigation consisted of observing commercial airplane spraying in the Philip, South Dakota area in 1953 and Huron, South Dakota area in 1954. Arrangements were made to have the pilot leave an unsprayed area on the upwind side of each field in order that yields could be taken from treated and untreated areas. Data were recorded on kind of crop, stage of growth, formulations and amount of 2, 4-D, kind and amount of carrier, time of day, humidity, temperature, soil moisture, wind direction and velocity, and weeds present. These data were collected and analyzed statistically showing no significant correlation to the wheat yields. However, in 1953 the mean yields of the sprayed area were lower than the mean yield of the unsprayed This was probably due to the fact that most of the wheat sprayed was in the late boot stage, indicating that the stage of growth of the wheat when sprayed, was the important factor.

Summary

1. Volume of carrier applied per acre had little effect on yield of wheat or weed kill.

2. There were no differences between airplane and ground applications of 2, 4-D on either wheat yield or weed kill.

3. There were no differences between oil and water as carriers of 2, 4-D on wheat yield or weed kill.

4. Three formulations of 2, 4-D - a butyl ester, an ethyl ester and a mixture of isopropyl and butyl ester - had similar effects on yield of wheat and weed kill.

5. Stage of growth was an important factor in yield reductions. Wheat appeared more susceptible in the boot and near heading stage than in the 5 to 7 leaf stage.

6. Further investigations are needed before conclusions can be drawn from the spray retention data. However, the work to date indicates that at the rates of application used there were no differences between air and ground applications, carrier or volume of carrier.

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SOIL APPLICATIONS OF 2, 4-D FOR THE CONTROL OF DEEP-ROOTED PERENNIAL WEEDS

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The deep-rooted perennial herbaceous weeds have long been one of the most serious weed problems on agricultural land. Over the past 20 years many methods have been used by farmers and an increasing number of research groups. Repeated complete tillage was found effective on several of the more persistent weeds. Partial or complete loss of crop revenue makes this method unattractive. Soil erosion may be severe. Soil sterilizing chemicals have also been used successfully to kill perennial weeds. High cost per acre, extended periods of sterility; and, in some case, extreme bulk have limited the use of these chemicals.

Foliage sprays of 2, 4-D have been used for about eight years to control field bindweed and Canada thistle in growing crops. Low cost per acre, ease in handling, and selectivity prompted extensive use in small grain and corn. After repeated applications over a period of 3 or more years it became apparent that only top-kills were being obtained in many cases. Even less satisfactory results have been obtained from foliage sprays of 2, 4-D on leafy spurge, Russian knapweed, and perennial smartweed. Various investigations have been undertaken to obtain greater movement of chemical downward into the extensive root systems of these perennial weeds. Improvement has been slow.

As early as 1946 work by Weaver and De Rose (1) and (2) indicated 2, 4-D applied on the soil could be absorbed by the roots and move upward through stem tissue that had previously been killed. This would indicate that movement of 2, 4-D which has been absorbed by roots is primarily through the non-living water-conducting xylem tissues. On this basis it might be possible to obtain better absorption and distribution of 2, 4-D throughout an extensive root system by applying the chemical to the soil. This report contains results obtained from such chemical applications made on the soil.

Initial treatments were made in November, 1948, on a leafy spurge infestation. 2, 4-D as a 5% ester dust was applied at rates of 10, 20, and 30 pounds per acre acid equivalent. Boron and sodium chlorate type soil sterilants were also used. Plant counts made in 1949 showed substantial stand reductions with all rates of 2, 4-D. These were comparable with the results obtained with the soil sterilants. One significant difference was evident - no soil sterility was apparent where 2, 4-D had been used as shown by the vigorous growth of native bluestems, side oats grama, and switchgrass. Samples for microorganism counts were taken from all plots 6 months after treatment. No change in numbers or species composition had occurred.

Additional tests were made in 1949 with fair results on Russian knapweed growing on a very saline soil. A third experiment was laid out on leafy spurge in November 1950. A micronized acid was used for the first time as well as two ester formulations of 2, 4-D. The micronized acid was sprayed on as a wettable powder and also in a dry mixture with 3 lbs. of Borascu per square rod. The Borascu was used to facilitate uniform spreading of the small quantity of 2, 4-D. Plant counts the following June showed the best kills with the 2, 4-D - Borascu mixture. These data are presented in Table 1.

Table 1. Comparison of 2, 4-D formulations on leafy spurge (Euphorbia esula) applied to the soil. Lincoln, Nebraska, 1950.

Treatments	Rates	Percentage Kill			
November 21, 1950	lb/A	6-1-51			
		I	II	III	Ave.
2, 4-D micronized acid*	20	88	87	96	90
(dry)	30	89	100	96	95
2, 4-D micronized acid	2	39	0	0	13
(spray)	10	0	0	0	0
	20	81	96	83	87
	30	100	88	60	83
2, 4-D butoxy ethanol ester	2	0	0	0	0
	10	0	77	75	50
2, 4-D isopropyl ester	2	0	0	0	0
	10	15	0	65	27
Check	no treatment	27% stand increase			

Average stand - 30 plants per sq. yard.
Soil type - Sharpsburg silty clay loam rolling phase.
Precipitation 11-21-50 to 6-1-51, 17 inches.
* Mixed with 3 pounds Borascu for spreading.

Further information was needed on the value of the various formulations of 2, 4-D in comparison to the micronized acid. Additional treatments on leafy spurge were made in the fall of 1952 and another series of treatments was made in the fall of 1953. Both fall seasons were unusually warm and dry with above normal temperatures and below normal precipitation. The 1952 treatments gave very good kills with a decided advantage for the amine salt and the micronized acid, (Table 2) CMU gave very little control of leafy spurge but killed all the native grasses. A mixture of 2, 4-D and 2, 4, 5-T acids in oil applied in a diesel fuel carrier was ineffective. The diesel fuel carrier may have interfered with normal absorption by the root system of the leafy spurge.

Table 2. Comparative effectiveness of three formulations of 2, 4-D, a brush mixture, and CMU on leafy spurge (Euphorbia esula) used as soil treatments. Lincoln, Nebraska, 1952.

Treatments	Rates	Percentage Kill			
October 18, 1952	lb/A	5-11-53			
		I	II	III	Ave.
2, 4-D (AS)	20	62	60	58	60
	30	82	96	83	87
	40	41	100	100	80
2, 4-D (isopropyl ester)	20	0	0	0	0
	30	89	76	39	68
	40	76	75	67	73
2, 4-D micronized acid	20	0	0	33	10
	30	93	100	50	81
	40	100	100	100	100
CMU	40	0	0	0	0
	60	68	45	79	64
	80	0	0	73	24
2, 4-D + 2, 4, 5-T (ACP572)*	20	100	0	0	33
	40	0	0	0	0

* Mixture of D & T acids in oil - applied in 40 gal. diesel fuel per acre. Plot area mowed and raked prior to treatment.

Ave. plants per sq. yd. October 1952 - - - - 30
May 1953 - - - - 140

Soil type - Sharpsburg silty clay loam rolling phase.
Precipitation 10-18-52 to 5-11-53, 8.3 inches.

Table 3 gives results obtained from the 1953 treatments and shows generally less effective results. It is believed that the mild open winter may have affected these results. February was exceptionally warm averaging 12.5°F above normal with several days of 68° to 70°. The iso-octyl ester was especially effective at the 40 pound rate of application with the amine salt next in effectiveness. Increasing the rate of application to 60 pounds per acre did not give proportionate increases in effectiveness, in some cases decreases resulted.

Table 3. Control of leafy spurge (Euphorbia esula) with four different 2, 4-D formulations as soil treatments. Lincoln, Nebraska, 1953.

Treatments	Rates	Percentage Kill			
November 10, 1953	lb/A	6-14-54			
		I	II	III	Ave.
2, 4-D (AS)	30	57	18	14	30
	40	100	86	57	81
	60	60	40	86	62
2, 4-D (isopropyl ester)	30	0	0	0	0
	40	31	0	0	10
	60	73	47	60	60
ACP 638 *	30	69	0	0	23
	40	0	19	0	6
	60	100	0	0	30
2, 4-D (iso-octyl)	30	0	0	0	0
	40	85	95	100	93
	60	69	81	100	83
Check	no treatment	Stand increase of 400%			

* 2, 4-D acid in oil.
Average stand - 15 plants per sq. yard.
Soil type - Sharpsburg silty clay loam rolling phase.
Precipitation 11-10-53 to 6-14-54, 14.2 inches.

In order to further test the method of soil applications, experiments on other perennial weed species were carried out. In November 1950 an infestation of hoary cress (Cardaria draba) was treated with 2 and 10 lb. per acre rates of isopropyl ester, butoxy ethanol ester and micronized acid formulations of 2, 4-D. The hoary cress was in a fall rosette stage of development with only 3 or 4 leaves above ground. Considerable regrowth appeared in 1951 especially on all plots treated at 2 lbs. per acre. Retreatments were made in April 1952 while the hoary cress was in a spring rosette stage of development. Plant counts taken in October showed almost complete kills in every case where 10 lbs. per acre had been applied with no difference in effectiveness between the three formulations used, (Table 4).

Table 4. Control of hoary cress (Cardaria draba) in fall rosette with three formulations of 2, 4-D. Lincoln, Nebraska, 1950.

Treatments	Rates	Percentage Kill			
11-7-50 and 4-8-52	lb/A	10-15-52			
		I	II	III	Ave.
2, 4-D (isopropyl ester)	2	100	73	87	87
	10	100	100	100	100
2, 4-D (Butoxy ethanol ester)	2	89	87	82	86
	10	87	100	100	96
2, 4-D micronized acid	2	88	87	67	81
	10	100	96	100	99
Check	no treatment	Stand increase from 30 to 46. Plants per sq. yard - 50%			

Soil type - Crete-Sharpsburg silty clay loam.

A similar trial on hoary cress was made in the spring of 1951 when the weeds were in a late rosette stage of development. Dry and spray applications of the micronized form of 2, 4-D acid were used to compare their effectiveness. Plant counts were made in April 1952 and retreatments were made approximately one month later. Results after only a single treatment showed the spray application gave better results at the 10 and 20 lb. rates of application. No difference existed where 30 lbs. had been used. It appeared likely that poor application was the direct cause for the poor kills with the dry micronized acid. Results are shown in Table 5. Percentage kill under 1952 represents a single treatment, under 1953, the result after two treatments.

Table 5. Control of hoary cress (Cardaria draba) in spring rosette with heavy rates of 2, 4-D and with CMU*. Lincoln, Nebraska, 1951.

Treatments	Rates	Percentage Kill				
5-8-51						
5-29-52	lb/A	4-16-52			Average	
		I	II	III	1952	1953
2, 4-D micronized acid (dry)	10	5	90	78	58	88
	20	78	94	96	89	95
	30	98	98	95	97	97
2, 4-D micronized acid (spray)	10	87	98	87	91	96
	20	96	98	94	96	97
	30	97	95	100	97	99
CMU†	40	99	100	100	99	99
	80	100	95	100	98	100
Check	no treatment	Stand increased from 64 up to 87 plants per sq. yard				

* 3-p-chlorophenyl 1, 1, -dimethyl urea.
‡ single application.
Soil type - Crete-Sharpsburg silty clay loam.
Precipitation 5-8-51 to 4-16-52, 36.8 inches.

Soil applications were next tried on two of the most difficult species to eradicate in this area; tanweed (Polygonum coccineum) and Russian Knapweed (Centaurea repens). Both species have very extensive root systems. Tanweed has also been called devil's shoestring because of the large number of tough, thick rhizomes which it develops. 2, 4-D micronized acid and CMU were applied as sprays in 80 gallons of water per acre June 9, 1952. Tanweed plants were 18" to 30" tall. No attempt was made to direct the spray onto the soil. Each chemical was applied at rates of 60 and 120 lbs. active ingredient per acre. Both rates of 2, 4-D had given better than 90 percent kill one year later, indicating that an even lower rate could be used. CMU did not effectively control tanweed in this test, (Table 6).

Table 6. Comparative control of tanweed (Polygonum coccineum) with CMU and 2, 4-D. Lincoln, Nebraska, 1952.

Treatments	Rates	Percentage Kill				
6-9-52	lb/A	6-11-53				
		I	II	III	IV	Ave.
CMU	60	14	0	0	73	22
	120	51	54	28	58	48
2, 4-D (micronized acid)	60	100	93	96	80	92
	120	97	85	100	88	93
Check	no treatment	Ave. stand 34 plants per sq. yard				

Soil type - Waukesha silty clay loam, a deep friable Terrace soil.
Precipitation 6-9-52 to 6-11-53, 23.2 inches.

An extensive infestation of Russian knapweed was subjected to various treatments starting in June 1953. At that time 2, 4-D treatments included isopropyl ester at 2 lbs. and 40 lbs. per acre, and a mixture of 30 lbs. 2, 4-D plus 10 lbs. of CMU per acre. In November 1953, 2, 4-D isopropyl ester, iso-octyl ester, amine salt, and 2, 4-D acid in oil were each applied at 30 and 40 lbs. per acre. Also included were concentrated Borascu at 12 lbs. per sq. rod and Polybor-chlorate at 8 lbs. per sq. rod. Plant counts taken June 25, 1954 showed a distinct advantage for the fall date of treatment over the June application date. The mixture of 2, 4-D and CMU showed no advantage over 40 lbs. of 2, 4-D alone. Nearly all formulations of 2, 4-D at the 40 lb. rate of application gave complete elimination of the Russian knapweed. Both Borascu and Polyborchlorate gave complete kills on this weed species, (Table 7).

Table 7. Control of Russian knapweed (Centaurea repens) with spring or fall applications of 2, 4-D and CMU. Seward, Nebraska, 1953.

Treatments	Rates	Percentage Kill			
Spring (6-4-53)	lb/A	6-25-54			
		I	II	III	Ave.
2, 4-D (isopropyl ester)	2	46	35	4	28
	40	91	40	0	44
2, 4-D (isopropyl ester)	30				
+	+				
CMU	10	73	20	42	45
Fall (11-12-53)	lb/A	6-25-54			
2, 4-D (isopropyl ester)	30	64	100	100	88
	40	100	100	100	100
2, 4-D (iso-octyl ester)	30	96	100	100	99
	40	100	100	100	100
2, 4-D acid (ACP 638)	30	96	100	100	99
	40	95	98	100	98
Conc. Borascu	12*	100	100	100	100
Polybor-chlorate	8*	100	100	100	100
2, 4-D (amine)	40	100	100	100	100
check	no treatment	Ave. stand 42 plants sq. yard increased to 44 plants sq. yard.			

* lb/sq. rod
Soil type - Carrington silty clay loam.
Precipitation - 11-12-53 to 6-25-54, 16.3 inches.

No soil sterility has been observed with any of the high rates of application of 2, 4-D. Bromegrass has shown some rather severe "onion leaf" from late fall and early spring applications, probably due to its cool-season periodicity of growth. Warm-season grasses appeared much more tolerant but may have merely escaped injury because of their later period of growth. Crop tolerances have not been worked out completely but some information is available. Oats, planted in March, developed sterile florets similar to that resulting from foliage applications at the jointing stage. The soil had been treated the preceding November at a rate of 40 lbs. of 2, 4-D per acre as the amine salt. A spring seeding of bluegrass germinated and grew normally following a fall application of 30 lbs. of 2, 4-D micronized acid.

A study to gain additional information on crop tolerance and rate of breakdown of 2, 4-D in the soil was carried out at Lincoln in the spring of 1954. The land was fall plowed and left rough over winter. Preparation in the spring consisted of one double disking about April 24, and another about June 4, just prior to planting the crops. The soil surface was sprayed with 40 lbs. per acre of amine salt and isopropyl ester on April 28. Corn, grain sorghum, and soybeans were planted June 5, approximately five weeks after the chemical was applied. Rainfall during the intervening period amounted to 5.8 inches with rainfall in May about one inch above normal. Approximately the same amount would be normal for the 4 month period of November 15, to March 15, at Lincoln, Nebraska. All three crops emerged and grew normally throughout the 1954 season. No yield differences were found for either formulation of 2, 4-D on any of the three crops grown in this test, (Table 8). Very few annual weeds survived in the chemically treated plots until late in the growing season.

Table 8. Yield of corn, sorghum, and soybeans on land treated with 40 lbs. 2, 4-D*. Lincoln, Nebraska, 1954.

Crops**	Amine salt	Isopropyl ester	Check
Corn	71.2	58.7	65.7
Sorghum‡	-----	----	----
Soybeans	34.7	35.2	35.2

* Applied 4-28-54.
** Planted 6-5-54.
‡ Small plots lost to birds - estimated yield 50 bu./A.
Precipitation 4-28-54 to 6-5-54, 5.8 inches.

Summary

1. A method of applying 2, 4-D to the soil at rates of 10 to 120 lbs. per acre is described and a theory for absorption and distribution throughout perennial weed root systems is discussed.

2. Leafy spurge and Russian knapweed are almost completely eliminated at rates of 40 lbs. 2, 4-D acid per acre applied in late fall.

3. All formulations of 2, 4-D appeared equally effective on knapweed.

4. Leafy spurge showed greatest susceptibility to 2, 4-D amine, 2, 4-D micronized acid plus boron, and 2, 4-D low volatile ester.

5. A brush mixture in oil was not effective indicating possible reduced absorption due to the presence of the oil carrier.

6. Better than 90% kills of tanweed were obtained and it is suggested that rates lower than the 60 lbs. per acre used should be tried.

7. Hoary cress was the most easily controlled of all species tested. Nearly complete elimination resulted from application rates as low as 10 lbs. per acre applied in early spring or late fall.

8. Cool-season bromegrass showed more injury than warm-season native grasses.

9. 40 lbs. 2, 4-D applied in November caused injury in oats planted the following March.

10. 40 lbs. 2, 4-D applied in April caused no injury in corn, grain sorghum, or soybeans planted 5 weeks later.

11. Soil type, soil temperature, and rainfall affect the rate of chemical removal from the soil.

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THE EFFECTS OF 2, 4-D AND MCP ON SORGHUM 1/

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The use of 2, 4-D and related chemicals has become a standard farm practice for weed control in several commonly grown farm crops. The effect of these chemicals on weeds is quite well known. These studies were designed to determine the effect of 2, 4-D and MCP on the yield of sorghum.

Proper pre-planting cultivation will often reduce the seriousness of weed infestations in sorghum. However, since sorghum is planted during the season when several common annual weeds normally emerge the crop may be infested with these annual weeds.

If the crop is planted in rows spaced widely enough to permit cultivation with conventional row crop equipment, it is usually desirable to perform the weed control operations mechanically. The planting method common in the Great Plains region is the use of narrower spaced rows as with small-grain drills where the row spacing may be varied from 10 to 30 inches by using all or part of the grain delivery tubes. Under these conditions, and when climatic factors prevent cultivation in wider spaced rows, chemical weed control becomes important.

Experimental Results

1950 Experiment

Two grain sorghum varieties, Midland and Westland, and one forage variety, Ellis, were treated with 0, 1/8, 1/4, 1/2, and 1 pound of 2, 4-D as an amine, isopropyl ester, and propylene glycol butyl ether ester. The two grain varieties were treated at the 5-leaf, the 8 to 10-leaf and the pollinating stages. The forage variety was treated in the 5-leaf, and 8 to 10-leaf stages.

Analysis of the yield data of the two grain varieties showed a highly significant difference in yields (0.01 level) due to rate of application, a highly significant stage x rate interaction and a significant variety x rate interaction.

The mean yield of the variety, Midland, dropped significantly even when 1/8 pound per acre was applied.

By contrast, it required 1/2 pound per acre to significantly reduce the yield of Westland. Yield data in Table I show that both grain varieties were most resistant to the chemicals when treated in the 5-leaf stage. Only when the rate was increased to 1 pound per acre was the reduction in yield significant. Sorghum treated in the 8 to 10-leaf stage was somewhat more sensitive to 2, 4-D than when treated in the 5 leaf stage as shown by the decided decrease in yield when the rate was increased from 1/2 pound to 1 pound per acre. The bloom stage was the most critical period for herbicide applications as shown by the significant drop in yield associated with the rate of only 1/8 pound of 2, 4-D per acre. There was no significant difference among the three types of 2, 4-D tested.

Table I. Mean yield in bushels per acre of Midland and Westland treated with three formulations of 2, 4-D in 1950.

Stage when treated	Rate: lbs. per acre 0	1/8	1/4	1/2	1
5-leaf	70.6	71.1	66.9	67.8	64.3
8 to 10-leaf	70.8	70.8	68.0	63.6	54.1
Pollinating	69.2	64.5	63.7	60.5	59.4

LSD = 4.7

Differences in test weights (Table II) were small but were significant when the data were statistically analyzed. Midland appeared to be more sensitive to 2, 4-D in respect to test weight than Westland. The test weight was reduced when Midland was treated at the 8 to 10-leaf stage.

Table II. Mean test weight in pounds per bushel of sorghum treated with five rates of three formulations of 2, 4-D in 1950 at three stages of growth.

Variety	Stage when treated 5-leaf	8 to 10-leaf	bloom
Midland	58.2	57.7	58.2
Westland	58.7	58.8	58.9

LSD = 0.2

When the data from the two varieties are combined the 5-leaf stage was definitely sensitive, as measured by test weight, to an application of 1 pound per acre (Table III). Plants in the 8 to 10-leaf stage were more sensitive than those in the 5-leaf stage as shown by the significant drop in test weight between 1/4 pound and 1/2 pound applications. It should be noted that the 1 pound rate applied at the 8 to 10-leaf stage gave lower test weights than the 1 pound rate applied at the 5-leaf stage. Test weights of grain from plants treated during the bloom stage did not appear to be affected by the rates used. In no case was there any indication that any application significantly increased test weight.

Table III. Mean test weight in pounds per bushel of Midland and Westland treated with three formulations of 2, 4-D in 1950.

Stage when treated	Rate: lbs. per acre 0	1/8	1/4	1/2	1
5 leaf	58.5	58.7	58.4	58.5	58.1
8-10 leaf	58.6	58.6	58.5	58.0	57.8
Bloom	58.7	58.6	58.4	58.5	58.5

LSD = 0.3

Data obtained from the forage variety include both the yield of grain and the yield of forage. Analysis of the data showed no effect of treatments on the yield of this variety.

1952 Experiments

Midland, a grain variety, and Ellis, a forage variety, were used in the 1952 experiments. Both varieties were treated with ester and amine formulations of 2, 4-D and MCP at 0, 1/8, 1/4, 1/2, and 1 pound per acre.

The applications were made in the 7 to 8-leaf stage, the 10 to 12-leaf stage and during the pollination period. The second date of application on Midland was made shortly after the growing point of the plants had changed from vegetative to floral and the small developing heads were approximately 1/2 inch long. Greatest yield reductions occurred as a result of this treatment, although the damage was not confined to this period. The ester formulation resulted in the greatest yield reductions but the amine caused some damage at rates necessary for control of many of the annual weeds which would be found growing in the crop.

There was no significant difference between the 2, 4-D and MCP, or between the ester and amine formulations. Applications of increasing rates caused somewhat less harm at the pollinating stage of growth than when applied at the more susceptible 7 to 8-leaf stage of development, (Table IV).

Table IV. The effect of rate of application of 2, 4-D and MCP applied at two stages on the yield in bushels per acre of Midland, 1952.

Stage when treated	Rate: lbs. per acre 0	1/8	1/4	1/2	1
10-12 leaf	39.2	37.2	36.0	30.4	25.5
Pollinating	38.4	39.5	38.6	35.8	33.3

LSD = 3.4

The yields obtained from this experiment do not clearly indicate the full extent of the chemical damage to the crop. In addition to the reduction in yield, there was considerable delay in maturity of some plots, particularly those treated in the 10 to 12-leaf stage with the heavier rates of application. In a few cases the damage to the main head was severe and a great deal of tillering occurred. These secondary heads were small, but numerous, and had not the growing season been favorable, maturity probably would have been delayed so that these late heads would not have contributed to the final yield of the crop.

Plots treated during the 7 to 8-leaf and 10 to 12-leaf stages showed typical brace root abnormalities and a small amount of lodging occurred. In addition there was noted damage to the feeder root system since the very fine feeder roots were much less in evidence on the treated plants than on the plants taken from the check plots.

A few of the treatments seemed to cause some growth stimulation at least in the vegetative parts of the plant. The yields were not necessarily affected but in some cases the plants treated at rather low rates, particularly the amine formulation, were several inches taller than those in the no-treatment plots.

Analysis of the grain and forage yields from the variety, Ellis, showed no significant difference. The grain yields from the MCP plots treated in the 7 to 8-leaf stage were somewhat higher than the grain yields from the other chemicals applied at later dates. This is the only instance in the experiments in which MCP showed evidence of being less damaging to the sorghum crop than 2, 4-D.

Germination percentage and test weight were not affected by any of the treatments applied in 1952.

1953 Experiments

A third experiment was conducted in 1953 in which Midland was treated with the ester and amine of 2, 4-D and the amine of MCP at 0, 1/8, 1/4, 1/2, and 1 pound per acre. The crop was treated at four stages of growth: the 4 to 6-leaf, the 9 to 11-leaf, pollinating, and early milk stages. There were variations among the experiments conducted in seccessive years; however, the rates and formulations of 2, 4-D were uniform throughout the period.

The first application in 1953 was made when the crop was approximately 4 inches tall and the plants had from 4 to 6 leaves. The plants that received 1/4 pound or more 2, 4-D ester showed typical brace root proliferation. Those treated with 1/2 pound or more 2, 4-D amine or MCP amine exhibited similar effects. This effect was noticeable in the field for approximately six weeks. During that time the root system of the affected plants appeared to be seriously injured as shown by considerable reduction in the number and length of the small feeder roots normally present on the sorghum plant. Following a period of rather heavy rainfall during July, the injured plants appeared to recover and there was little or no difference in the average yield of the plants treated at the 4 to 6-leaf stage development and the no-treatment plants.

The second application was made when the crop had 9 to 11 leaves and was approximately 18 inches tall. At the time of treatment, the sorghum was growing well and the soil was wet. The sorghum growing point had recently changed from vegetative to floral and the small

heads were approximately 1/2 inch long. This stage corresponded closely to the second stage of growth in the 1952 experiment. It was during this period that the greatest reductions in yields occurred in both years.

Treatments applied during the pollinating period did not result in the low yields previously obtained from treating the crop during this period. The 1 pound rates of the three chemicals caused considerable reduction in yield but the reductions were not so great as those resulting from treatments applied at the 9 to 11-leaf stage of development.

The fourth application was made after pollination was complete and most of the kernels had formed and were in the early milk stage of development. There appeared to be little or no effect from these applications.

Table V. Effect of 2, 4-D ester, 2, 4-D amine, and MCP amine on the yield in bushels per acre of Midland when applied at different stages in 1953.

Chemical & Formulation	Stage when treated 4-6 leaf	9-11 leaf	Pollinating	Soft Dough
2, 4-D ester	67.1	61.2	68.8	68.8
2, 4-D amine	72.2	51.5	72.7	70.0
MCP amine	72.5	56.5	66.7	70.1

LSD = 4.4

Treatments applied early in the season delayed maturity up to one week. The delay of maturity increased with higher rates of application. Also, the higher rates during the 9 to 11-leaf stage of development caused a noticeable increase in the number of tillers produced by the plants and thus caused uneven ripening of the crop. The third and fourth dates of application appeared to have little effect either on the date of maturity or on the number of tillers produced. As in 1952, several plots showed an increase in plant height due to treatment.

Observations of commercial spraying and results of experiments indicate that the sorghum plant changes rapidly from a period of relative tolerance to 2, 4-D and MCP to a period of rather extreme susceptibility. For this reason an experiment was designed in 1953, in which the crop was treated at approximately three-day intervals throughout its growing season.

The rate of application was 1/2 pound of 2, 4-D ester per acre and applications were begun when the crop had four leaves and was approximately 4 inches tall. Additional plots were treated throughout the season until the grain was in the soft dough stage. Analysis of the data indicates that there was a least significant difference of 10.5 bushels per acre. The average no-treatment yield was 67.7 bushels. Thus, the 67.7 plus or minus 10.5 gives a range of 57.2 to 78.2 bushels per acre.

Treatment number 8 applied when the crop had 9 leaves and was approximately 16 inches tall, resulted in a yield of 58.5 bushels per acre. Two days later, treatment number 9 was applied and the yield dropped to 53.4 bushels per acre. Treatment number 9 was applied on the same day as the 9 to 11-leaf stage of development in the previously discussed 1953 experiment. The following three treatments made during the 10-leaf to early boot stages resulted in yields significantly lower than the no-treatment plots. Thus for a period of eight days, the crop was severely damaged by 2, 4-D applications, (Fig. 1).

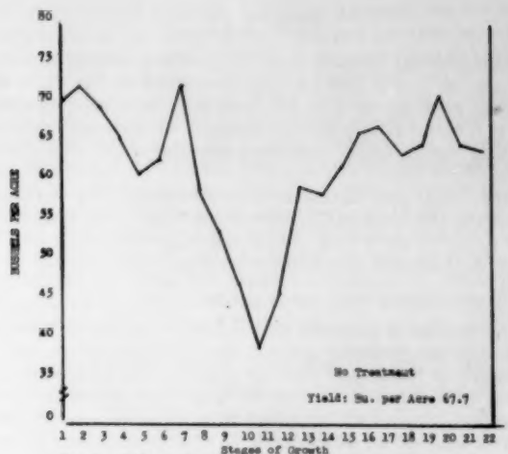

Fig. 1. Yield per acre of Midland sorghum treated at 22 stages of growth with 1/2 lb. 2,4-D ester, Hays, Kansas

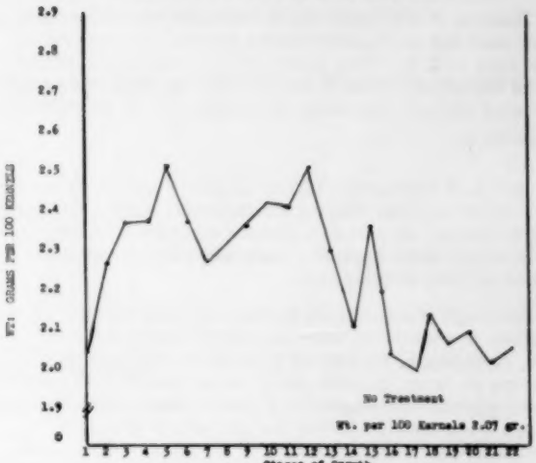

Fig. 2. Weight per 100 kernels of Midland sorghum treated at 22 stages of growth with 1/2 lb. 2,4-D ester, Hays, Kansas.

Subsequent treatments during the late boot, heading, and pollinating period did not result in significant yield reductions. No stage of treatment yield exceeded the check plot yields by more than half or the LSD. There was no significant effect in the test weight from any of the treatments.

Determinations were made of the average weight per hundred kernels harvested from the various plots treated at the 22 stages of growth and the no-treatment plots. The average of the no-treatment plots was 2.7 grams per hundred kernels. The LSD was found to be 0.18 gram, which gave a range from 1.89 to 2.25 grams. All stages from the 5-leaf or second date of application, to the 75 percent headed or 15th stage of application, except the 25 percent headed, had significantly higher mean weights per hundred kernels than the no-treatment plots. With only one exception, the highest weights per hundred kernels were found in the ninth to twelfth stages of growth. These stages correspond directly with the lowest yields obtained. Thus it would seem to indicate that 2, 4-D applications reduced the number of kernels and resulted in increasing kernel weight.

Summary

Experiments conducted in 1950, 1952, and 1953 on the effect of 2, 4-D and related chemicals on the yield of sorghum have shown that the crop may be seriously damaged if treated at susceptible stages. Some yield reductions may result when treated at any stage.

Stage of growth appears to be the most critical factor in treating the crop with these chemicals. Applications made prior to the 8 to 9-leaf stage (approximately 12 inches tall) seldom resulted in seriously decreased yields.

The period of greatest susceptibility appeared to be at the time the growing point of the plant changed from vegetative to floral and shortly after. This period of susceptibility continued until the plant was headed and pollination completed, although in at least two experiments the crop was not so susceptible to 2, 4-D in the pollinating period as it was in the early boot stage.

Results of one experiment indicated that the sorghum plant may change rapidly from a period of comparative tolerance to 2, 4-D to a period of extreme susceptibility to the chemical. Therefore, if the crop is to be treated for weed control, the stage of growth should be carefully considered.

Rates of application follow stages of growth in importance of the various factors considered. Increasing rates of application, in general, caused decreased yields, particularly when applied during the more susceptible stages of crop development.

Although when considered as a general factor, formulations of chemicals were not significantly different from each other, there was a tendency for the ester formulations to cause greater yield reductions than the amine formulations. This again was particularly true when the sprays were applied during the periods of greatest susceptibility.

One year, there was no significant difference between the reaction of two grain varieties to applications of 2, 4-D. In none of the reported experiments was there a significant difference between ester and amine formulations of 2, 4-D or MCP and in no case was there a significant difference between 2, 4-D and MCP.

Factors other than yield may be important in considering the use of these chemicals on the crop. Abnormal brace root development nearly always occurred following applications of 2, 4-D or MCP. In many cases, applications made early in the season delayed maturity. If the chemicals are applied during periods of extreme crop susceptibility, there may be damage to the developing sorghum head which will result in excess tillering. Later maturing heads might interfere with harvesting operations.

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DALAPON AND MALEIC HYDRAZIDE FOR CONTROL OF QUACKGRASS

K. P. Buchholtz 1/

Studies on the use of foliar applications of herbicides at low rates for control of quackgrass were started in 1951. This method of treatment was investigated because it was hoped that more economical applications with a more rapid response and with less hazard of soil residue might be developed for control of this weed than had previously been available.

Foliar applications are likely to result in more efficient use of materials for the extreme dilution of the herbicide when the soil mass is avoided. In addition there is no necessity for precipitation to leach the herbicide to the root zone of the treated plants. To be fully effective an herbicide applied to the foliage of perennial plants must be translocated. It must also kill by a secondary effect rather than by a direct toxic action that destroys the leaf tissue.

In preliminary trials it appeared that maleic hydrazide might be useful for control of quackgrass if this approach was utilized. Applications were made in the spring after the quackgrass foliage had developed a growth of four to eight inches. After varying intervals the treated areas were plowed, the soil fitted and crops planted. The degree of control was determined by making counts of quackgrass shoots about 6 weeks after treatment. Additional observations were made later in the season to determine how long a period of control was obtained.

The earlier trials indicated that the application rate and interval between treatment and tillage of the plots were of considerable importance. If the interval was too short only partial control was obtained, possibly due to incomplete translocation. An excessively long interval also gave only partial control, probably due to the tendency of the plants to recover from the MH treatment when the leaves were left intact. Most favorable results occurred when the interval was from 4 to 8 days. Initially applications were made at 16 lb/A but further trials showed that essentially the same results could be obtained with 8 or even as little as 4 lb/A of MH.

Results of a typical trial are shown in Table 1. The area was an old alfalfa sod heavily infested with quackgrass. Two hundred lb/A of ammonium nitrate were broadcast on the area on April 15. On May 12 specified plots, 13 by 50 feet in size, were sprayed with 8 lb/A of MH as the sodium salt using water equivalent to 20 gal/A. On May 16 the area was plowed and fitted. Corn was planted on May 20 and the entire area was then treated with CMU at 2 lb/A of DNBP at 6 lb/A to control the growth of annual weeds. Check plots were cultivated or were allowed to go without either tillage or MH treatment. Counts of quackgrass shoots on each plot were made on June 11. At maturity the corn was harvested and yields obtained. The area was fall plowed and counts of quackgrass were obtained again in June, 1954 after a thorough tillage on May 18, 1954.

Table 1. Control of quackgrass with maleic hydrazide (MH)

Treatment 1953	Shoots/sq. ft. 6/11/53	6/8/54	Corn yield bu/A
No cult.	30.8	7.3	44.3
Cult.	26.8	3.5**	53.0*
MH 8 lb/A	1.8**	2.0**	63.0**

The data show that the shoot development of quackgrass was greatly reduced by the treatment with MH. The MH appeared to give nearly complete inhibition of bud and shoot growth. Very little growth appeared on the treated plots during the remainder of the summer and the following year the stand of quackgrass was still scanty. The corn on the treated areas showed no symptoms of toxicity at any time and produced a substantially higher yield of grain then that on the check plots.

In 1954 a more detailed trial showed that 2,2-dichloropropionic acid (dalapon) and 3-amino-1,2,4-triazole (ATA) as well as MH have promise for the control of quackgrass when applied as foliage sprays. An old alfalfa sod heavily infested with quackgrass was selected for the trial. Ammonium nitrate at the rate of 200 lb/A was applied early in April. On May 6 the three herbicides were applied at rates of 4 and 8 lb/A in water equivalent to 20 gal/A. The entire area was plowed on May 13. After fitting the soil, corn was planted on May 20 and the area was then treated with CMU at 2 lb/A or DNPB at 6 lb/A to control annual weeds. Shoot development of quackgrass was determined on June 8. Various observations were made on the growth of the corn, and at maturity corn grain yields were obtained. Some of the data collected are summarized in Table 2.

Table 2. Control of quackgrass with MH, ATA and DAL

Treatment lb/A	Shoots/sq. ft. 6/8/54	Corn height-in. 7/19/54	Corn yield bu/A
None	19.9	53.2	53.5
ATA - 4	9.3**	62.6**	82.2**
ATA - 8	2.2**	61.7**	87.7**
DAL - 4	1.6**	62.7**	88.2**
DAL - 8	.1**	60.4**	88.2**
MH - 4	.5**	65.0**	87.1**
MH - 8	.2**	64.4**	87.2**

MH gave excellent control of quackgrass at both the 4 and 8 lb/A rates as in previous years. Dalapon also gave excellent control and in this trial there was no evidence of injury to the corn following the treatment, with either the 4 or 8 lb/A rate. The control obtained with ATA was less complete, particularly at the 4 lb/A rate. The corn yields indicate that the competition due to quackgrass had been greatly reduced even with this treatment, however the control obtained throughout the season was probably better than indicated by the initial shoot counts. In no case did ATA appear to be toxic to the corn when applied in the manner described.

Experience has shown that a high degree of control with quackgrass can be obtained by use of MH, dalapon and probably ATA. Detailed studies with dalapon and ATA have not been completed to determine the most favorable rates of application and intervals between treatment and tillage. When utilizing an herbicide that is absorbed through the foliage it is essential that as dense a stand of shoots as possible be obtained before treatment. Growth of this type is favored by delaying all tillage until after treatment. Tillage prior to treatment, even though several months in advance, is likely to bury some of the rhizomes deeply and prevent maximum shoot development. A rapid and more complete development of shoots is favored by making applications of a nitrogenous fertilizer early in the spring. Experience also indicates that the most favorable results follow applications made when the initial growth of the quackgrass is from 4 to 8 inches tall. Applications to taller growth later in the season or to regrowth following tillage or clipping have not been as successful as those made earlier. MH and ATA have never given any evidence of residual soil toxicity on a number of crops. In some cases sensitive crops have shown symptoms of toxicity when planted on areas treated a few days previously with dalapon at rates of from 4 to 8 lb/A.

MH and dalapon appear to be effective due to the marked bud and shoot inhibition induced in the quackgrass plant. The rhizomes are not killed rapidly but eventually they die if top growth cannot be developed. The action of ATA is more complex. It produces a noticeable inhibition of shoot regrowth and in addition the regrowth is usually deficient in chlorophyll.

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DALAPON FOR QUACKGRASS CONTROL

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The sodium salt of 2,2-dichloropropionic acid has recently been introduced as an herbicide under the name Dalapon. Preliminary testing showed it to be selectively active against members of the grass family, similar in action to TCA. Greenhouse and field experiments concerning the action and translocation of Dalapon were carried out, using quackgrass (Agropyron repens) as a test plant.

In the field Dalapon was used on quackgrass at 5, 10, 20 and 40 pounds acid equivalent per acre in 40 gallons of water. TCA at 20 and 40 pounds per acre was used for comparison. Tween 85, a commercial wetting agent, was used with Dalapon at 0.1 percent. Two experiments were run, one in the spring and one in the fall. The field was a second-year alfalfa and red clover meadow that was heavily infested with quackgrass. The herbicides were applied: (1) without cultural control methods, (2) about 10 days before plowing, and (3) about 10 days after plowing.

All rates of Dalapon killed at least a large part of the quackgrass foliage present. However, recovery on the unplowed plots that received only 5 and 10 pounds per acre was fairly rapid. The plots that received the higher rates had at least 10 percent stands the following spring. This was true of both spring and fall treatments.

Due to an extremely dry summer, plowing alone killed almost all quackgrass in the spring-treated plots. This masked the effects of the herbicides.

Treatment of the quackgrass with Dalapon in the fall without plowing gave better control than did the spring treatment. Combined chemical and cultural treatments were much better than either alone, but whether Dalapon was applied before or after plowing made no difference in the final results. Dalapon was approximately twice as effective as TCA, but in no instance was complete eradication obtained.

In the greenhouse two-inch sections of healthy quackgrass rhizomes were planted in 4-inch clay pots. The resulting shoots were treated with Dalapon at one of four stages:

1. Plants 3 - 6 cm. tall, no leaves unrolled.
2. Plants 6 - 12 cm. tall, one leaf unrolled.
3. Plants 12 - 18 cm. tall, two leaves unrolled.
4. Plants over 18 cm. tall, three or more leaves unrolled.

Three types of treatment were given: (1) The plant and soil were sprayed over-all, (2) the shoot was protected and the soil treated, (3) the shoot was immersed in Dalapon solutions with the soil protected. Plants were rated as to foliage appearance 20, 30, 60 and 75 days after treatment. At least five pots were used for each treatment.

All three methods of treatment were equally efficient in killing quackgrass. Solutions of 10 and 100 ppm. caused no injury; 1,000 ppm. caused severe foliage injury by 60 days; 5,000, 10,000 and 50,000 ppm. caused foliage death within 60 days. Usually new shoots came up from the rhizomes within 60 days. The four different height groups reacted similarly.

In about 40 percent of the pots, two or more shoots arose from one rhizome piece. These pots were used to study the translocation of Dalapon. One of the two shoots was treated by immersion and translocation assumed to have occurred if the untreated shoot showed symptoms of herbicide injury. Dalapon was found to translocate very readily and in either direction along the rhizome. The amount of translocation increased as the concentration of Dalapon was increased from 1,000 ppm. to 50,000 ppm. Translocation was poorest in the 0 to 6 cm. shoots and best in shoots over 12 cm. tall. Injuring the leaves before treatment did not increase translocation.

Several workers have found that the translocation of 2,4-D is associated with the movement of the products of photosynthesis. In an effort to determine whether Dalapon moves in the same way, plants were placed in the dark for 48 hours to exhaust the leaves of photosynthates, treated by immersion of the foliage for 15 seconds, returned to the dark for 24 hours and then carefully washed and returned to the light. This treatment greatly decreased the translocation of Dalapon but a slight amount of translocation was noted. The first plants were treated in the light, but later treatments in complete darkness showed that this brief exposure to light did not affect the amount of translocation.

In an effort to increase translocation in the dark by adding sucrose, plants were treated in the dark as above but by the jar method, both with Dalapon alone and with Dalapon plus a 10 percent sucrose solution. The addition of sucrose to the solution did not increase translocation.

In order to determine the speed of absorption and translocation of Dalapon by quackgrass foliage, shoots were treated and then washed or cut off at various periods of time after treatment. Dalapon apparently entered the leaves quickly, as washing five minutes after treatment did not prevent severe damage to the treated leaf. Within 30 minutes enough Dalapon had entered to kill the treated shoot and to translocate and kill the untreated shoot. However, it took three hours for a toxic concentration of Dalapon to move into the rhizome.

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CHEMICAL AND CULTURAL CONTROL OF FIELD BINDWEED ON THE HIGH PLAINS OF TEXAS 1/

Allen F. Wiese and H. E. Rea 2/

In the Panhandle of Texas there are approximately 32,000 acres of bindweed growing on 28 percent of the farms. In other words 1,580,000 acres of farm land of the area are affected by the weed. Because of the seriousness of the situation, bindweed control experiments were initiated at the Amarillo Experiment Station in 1949. The soil type is Pullman clay loam, and the soil profile, which is underlaid with caliche, is about six feet deep. The low average rainfall (18.4 inches) accompanied with a high evaporation rate is seldom enough to wet the entire soil profile.

The chemical, cultural and competitive crop treatments have been replicated three times each year and have been repeated for three years. Cultivations were made (4 inches deep) with a 30-inch sweep plow. This plow was very satisfactory for cutting off the weeds, and it reduces the hazard of wind and water erosion by leaving the crop residue on the soil surface. Intensive cultivation practices alone were carried out at 9 and 15 days after the bindweed emergence. During the first year of each experiment the average periods of cultivation between the 9 and 15 day treatments were 22.5 and 28.8 days respectively. The intervals between cultivations were long because of frequent dry spells which prevented the emergence of the weeds. The stands of bindweed were reduced 89 percent in 3 years by both treatments. Two or three annual applications of 2,4-D ester and amine to non-cropped land has given 80 and 73 percent control respectively.

Growing competitive crops along with intensive cultivations or 2,4-D treatments has proven to be the most practical approach to bindweed control in the area. A fallow-wheat-fallow rotation using intensive cultivation during the fallow periods gave 92 percent control in three years. Besides giving the best control of any practice tried, this method of farming has proven to be the most profitable method of wheat production for the area. Wheat grown continuously was a successful competitive crop if 2,4-D was used at least once a year either in between the crops or directly on the wheat. Intensive cultivation 9 days after the emergence of the bindweed in between annual crops of either sorghum or wheat has not proven to be a good method of bindweed control giving only 70 percent reduction in a three year period. Wheat was a better competitive crop then sorghum during dry seasons.

Wheat became established in the late fall and winter when the bindweed was dormant and in the spring it grew rapidly enough to shade the weeds. Sorghum planted in June when the weeds are growing vigorously could not become established if the season was dry.

1/ Contribution from the Amarillo Experiment Station, USDA, and Texas Agricultural Experiment Station. Approved as T.A.E.S. T.A. 2104

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SOME LABORATORY AND FIELD TESTS OF BROADCAST NOZZLE SPRAYERS 1/ 2/

L. A. Liljedahl 3/ and John Strait 4/ 5/

General Discussion

In practice there appear to be a number of inconveniences in the use of standard farm sprayers. These include difficulty of maneuvering around trees and brush at the edges of fields and pastures, and difficulty of manipulation in spraying fence rows and other odd jobs. It is hard to get the farmer to clean and maintain the booms, hoses, drop pipes, and nozzles. The farmer must constantly watch the multiplicity of nozzles to be sure none are plugged.

For these and other reasons, many farmers have adapted the broadcast nozzle sprayer to general farm spraying, including field crops, whether it is recommended for the purpose or not. Some manufacturers of sprayers have reported that in certain areas more than a third of the sprayers now being sold are of the broadcast nozzle type.

Shanks (1) found that uniformity of boomless nozzles tested ranged from 1-1/2 to 1 down to 6 to 1, and that a cross wind narrows swath width considerably. Foster (2) reported that the spray pattern of boomless nozzles available in 1952 was upset by wind to such an extent that a satisfactory job could not be obtained consistently. Corl (3) reported from tests of one particular model of broadcast nozzle that it was possible to appreciably improve its design. Weber (4) discussed the problems surrounding the use of the boomless sprayers, and pointed out the intrinsic shortcomings and limitations in applications of this type of nozzle. Terry (5) and Barger et al (6) pointed out that a spray nozzle need not have a uniform pattern to produce a reasonably uniform deposit if overlapped properly.

Corl (3) indicated that at least one commercial model of broadcast nozzle yields a distribution of spray material equally as uniform as standard boom and nozzle sprayers. In general, however, recommendations have been that if the nozzles are used at all, they should be restricted to fence rows and rough pastures, mainly because of a lack of suitable information upon which to base any other safe recommendation.

Object of Study

The object of this study is to investigate the characteristics of the broadcast nozzle and the possibilities of its applications to general farm spraying.

Broadcast nozzles operate by projecting spray to the side. The distance the spray travels depends upon the size and velocity of the droplets. For any given liquid being sprayed, droplet size is generally inversely proportional to the pressure and directly proportional to the orifice size of the nozzle. The principles involved in droplet formation and droplet trajectories have been fairly well established, (7), (8). In specific application of known theory, however, complicated boundary conditions are introduced and the mathematics involved becomes impractically complex. Thus, work on nozzle characteristics and their design proceeds largely on a trial and error basis.

There are a number of distribution patterns which, when overlapped, will theoretically yield uniform coverage. Figure 1. shows a straight line pattern; this is approximated by ordinary boom sprayers. This figure shows the effect of a small error in judging swath width. Figure 2. shows a possible triangular pattern. If this pattern were from a broadcast nozzle, which in general would have large droplets at the outside of the swath and fine droplets in the center, the resulting swath would have a good range of droplet sizes all over. This figure shows that errors in judging swath width do not have nearly such an adverse effect with this distribution pattern. However, the effect at the edge of the field would be undesirable.

Compromising the patterns previously shown would be a trapezoidally shaped pattern, which would allow some misjudgments of swath width and yet would allow spraying fairly close to the edge of the field. This is shown in Figure 3.

What shape should the end of such a trapezoidal pattern have? We will assume that an operator can judge his swath width within plus or minus 10%, and that in the event of a 10% error, we can tolerate a 50% change in concentration for 10% of the swath width. Laying this out graphically as shown in Figure 4., we see the resulting pattern would be essentially flat for 0.4 of the swath width of either side, and then would fall off to zero in the next 0.2 swath width. The coverage resulting from the specified errors is shown. A sinusoidal curve having the same maximum slope would yield approximately the same results.

It must be borne in mind that when we refer to a line in a pattern, we are actually speaking about a regression line of the actual distribution. The actual distribution must have a reasonably limited deviation about the regression line. Figure 5. shows a typical distribution pattern with a solid line and its approximating regressions as a broken line.

One sample of each of three major commercial nozzle designs available in the spring of 1954 was purchased for testing. Nozzle #3 consists of two large off-center nozzles, one spraying in each direction, a smaller wide-angle nozzle spraying straight down to fill in the center, and a jet nozzle directed up at an angle on each side, so as to fill in on the edge of the swath. It is a cluster of 5 individual nozzles, in all. Nozzle #4 consists of a circular polished plate placed against an especially shaped face, from the center of which the spray

liquid flows. This produces a fan shaped flat sheet of water which sprays out in both directions. Nozzle #5 consists of two large off-center nozzles, one spraying in each direction, and a smaller wide-angle nozzle spraying straight down to fill in the center. It is a cluster of 3 individual nozzles, in all.

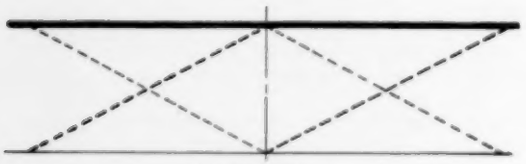
RECTANGULAR PATTERN

COMPOSITE

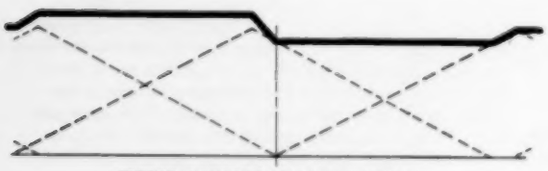
EFFECT OF ERROR IN JUDGING SWATH

Fig. 1.

TRIANGULAR PATTERN

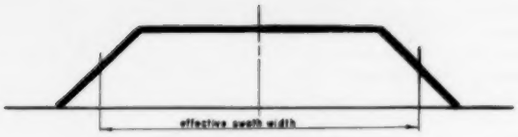


COMPOSITE



EFFECT OF ERROR IN JUDGING SWATH

Fig. 2

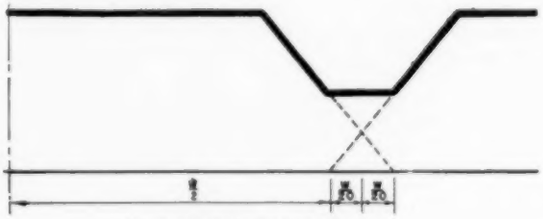


TRAPEZOIDAL PATTERN

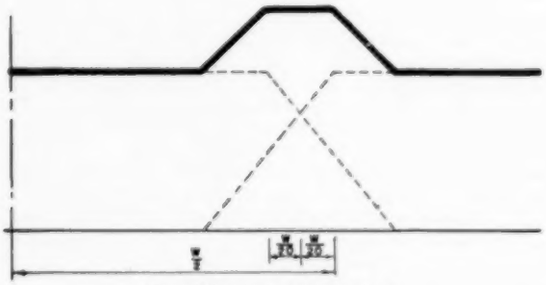
COMPOSITE

EFFECT OF ERROR IN JUDGING SWATH

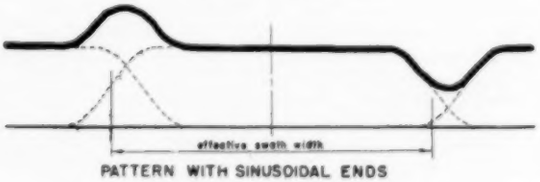
Fig. 3



DEVELOPMENT FOR SKIP



DEVELOPMENT FOR OVERLAP



PATTERN WITH SINUSOIDAL ENDS

Fig. 4

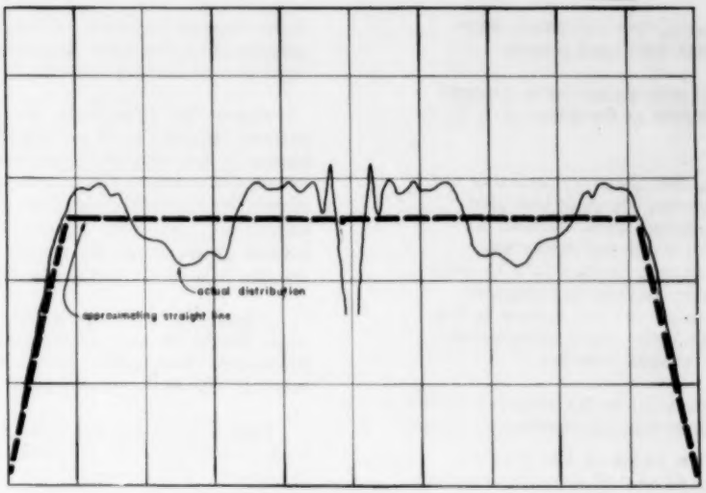


Fig. 5

Laboratory Tests

The nozzles were first tested in the laboratory to learn their general characteristics in still air and to gain information upon which to base later field tests.

The apparatus used in the laboratory tests consists of a mounting stand with a pumping unit below, a collector unit, and return troughs. The collector unit consists of 32 sharply divided troughs 3" wide and 36" long, placed side by side. The spray falling in each trough is collected in a graduated cylinder below. Since the unit is only 8' long, it is mounted on wheels to cover an entire side of a nozzle swath.

The procedure was to mount the nozzle on the stand at the manufacturers recommended settings and apply tap water at a certain pressure. The collector was placed with the edge of the end trough under the nozzle. The spray was collected for a two minute interval, and the amount in each cylinder recorded. The collector unit was rolled out eight feet from the nozzle and the procedure repeated. The procedure was again repeated at additional positions at eight foot intervals to cover the entire half swath.

The data collected was graphed after being smoothed by taking a running average of four consecutive points. The original unsmooth data was analysed to determine the coefficient of variation within the manufacturers recommended swath width.

Figure 6. shows the results of the laboratory tests at 15, 30, and 60 pounds per square inch pressure. All individual graphs are equal to 50 foot width, and the divisions shown represent 5 foot increments. The vertical divisions correspond to units of 10 ml/in/min. At 15 psi the distribution of all nozzles was very irregular. The pattern of #4 and #5 drop off sharply. #3 might yield a reasonable pattern if lapped at 14 feet. At 30 psi the patterns improve considerably. #3 is a very narrow topped trapezoid, #4 is somewhat wider, and #5 drops off quite sharply at the ends. It appears the best swath width is about 44 feet for #3 and #4, and 46 feet for #5. Based on the assumptions of the earlier discussion, #5 drops off too sharply at the ends. At 60 psi the patterns become rather poor again. Nozzle #5, however, is fairly uniform and the pattern does not drop off too rapidly. The best swath width is about 50 ft. The coefficient of variation for the patterns shown in this figure, based on a swath width of 20 ft., is as follows:

	15 psi	30 psi	60 psi
#3	38.8	15.0	25.4
#4	38.7	16.2	66.0
#5	36.0	34.0	35.7

The coefficient of variation for a conventional sprayer using 80° nozzles spaced 20" apart, at a pressure of 40 psi, under similar condistions, is:

height	18"	21"	24"	27"
C. V.	13.4%	13.6%	15.1%	16.9%

Based on these tests of a conventional sprayer, it was decided that for purposes of discussion in this paper, any distribution with a coefficient of variation less than 20% would be considered satisfactory for general field spraying.

Field Tests

Using the laboratory tests as a background, field tests were planned to study the effect of wind and other factors not present in the laboratory. In preliminary greenhouse tests, it was found that soybeans given a pre-emergence spray of TCA showed a fairly linear dosage-damage response in the range of 1 to 10 #/A of TCA. It was decided to apply a pre-emergence spray of TCA on soybeans using the broadcast nozzle. The field distribution pattern could then be assessed from the damage to the soybeans across the swath from root absorption of the TCA.

Fifty foot square plots of soybeans were planted. A broadcast sprayer made a pass along one edge, three days after planting, spraying TCA at a rate of 5#/A, based on the average distribution obtained in the laboratory. This was done both parallel and perpendicular to the wind and with each of the three nozzles at 15, 30, and

60 pounds pressure. In addition, one full swath was taken perpendicular to the wind with each nozzle.

At the same time, comparison strips were sprayed with a small conventional sprayer at the rates of 1, 3, 5, 7, 9, and 15 #/A TCA.

Forty days after planting, the characteristics of the comparison strips were observed. In each test plot three equally spaced 20-inch strips were marked off perpendicular to the side from which the spray was applied. These strips were in turn divided into 20-inch squares. The field distribution pattern was obtained by comparing the soybean damage in each square in the strip to the comparison strips. The three patterns obtained from each plot were averaged together.

The results of tests run parallel to the wind are shown in Figure 7. The sprayer speed was approximately 4 mph and the wind velocity was in the range of 4 to 7 mph (Beaufort #2 scale). Nozzles #3 and #4 were run heading into the wind, and nozzle #5 was run with a tail wind. While comparative tests into the wind and with a tail wind are not available, for each nozzle, we can observe two general facts. In nozzle #3, which is the off-center type composed of 5 nozzles, we see the pronounced effect of pressure on swath width. This can obviously be attributed to the smaller spray droplets, produced at higher pressures, which do not carry as far. In nozzle #4, pressure has little effect upon swath width. In this nozzle, droplet size apparently does not vary so much with pressure, and must generally be smaller than those of #3. The dotted line portion of this graph represents the part of the swath where the soybeans had been killed by the TCA, so that dosage at that point is not known. The peak in the center of patterns of nozzle #4 probably are not true to the actual distribution, and should be ignored. This is because the test was made as two half swath tests, and in each case the spray in the opposite direction was intercepted and allowed to run onto the ground in a small stream at the centerline. The killing of the beans in the first 20-inch strip was probably due to some small lateral movement of the TCA in the soil, and absorption by widely spread roots. By comparing nozzle #3 with #5, which are somewhat similar in principle and in pattern obtained in the laboratory, we can observe the general difference in swath width when heading into the wind as compared with a tail wind.

The results of tests run perpendicular to the wind are shown in Figure 8. The small black triangle below each graph, indicates the position of the nozzle in the tests; the wind is from the left. One test with each nozzle was run with a full swath, the others represent half swaths. Most apparent in these graphs is that the general pattern shape and width is relatively unaffected by the pressure, and that none approach the idealized shapes discussed earlier.

Figure 9. compares the effect of parallel and perpendicular wind on the pattern of nozzle #3. Droplet sizes were large enough at low pressures so that when parallel to the wind, the pattern characteristics are similar to those obtained in the laboratory. As the pressure increases, this similarity disappears.

We next consider how we might use broadcast nozzles to obtain reasonably uniform coverage in general field spraying, in view of their characteristics indicated by these tests. As mentioned earlier, other workers have pointed out that a spray nozzle need not have a uniform pattern by itself to produce a reasonably uniform deposit if overlapped properly. Consequently, the effect of overlapping the quite irregular spray patterns obtained in the field was next investigated.

Figure 10. illustrates the effect of overlapping the pattern obtained from nozzle #3 when spraying perpendicular to the wind at 30 psi pressure. The top graph shows the original single pattern. The second graph shows the coverage resulting from overlapping to a 40 ft. swath; the coefficient of variation (C.V.) is 37.3%. The bottom graph shows the coverage resulting from overlapping to a 20 ft. swath; the C.V. is reduced to 20.8%.

Figure 11. illustrates the same approach to the pattern from nozzle #4 when perpendicular to the wind at 15 psi pressure. The bottom graph shows the effect of overlapping to a 20 ft. swath; the C.V. is 11.4%.

Figure 12. illustrates the same approach to the pattern from nozzle #5 when perpendicular to the wind at 30 psi pressure. The second graph shows the result of overlapping to 30 ft. swath; the C.V. is 28.0%. The bottom graph represents a 15 ft. swath; the C.V. is 16.4%.

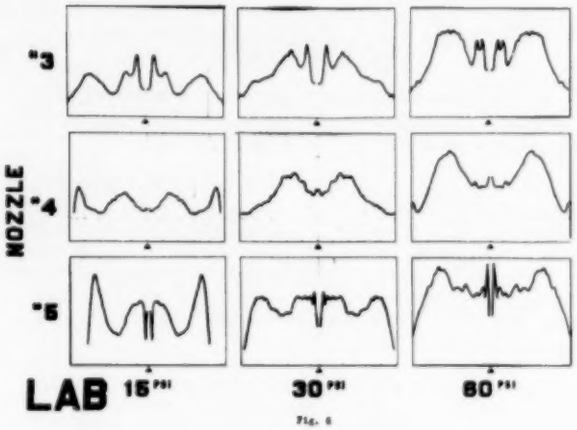


Fig. 6

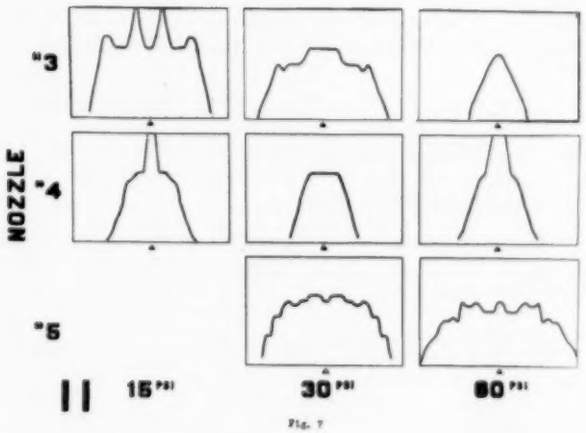


Fig. 7

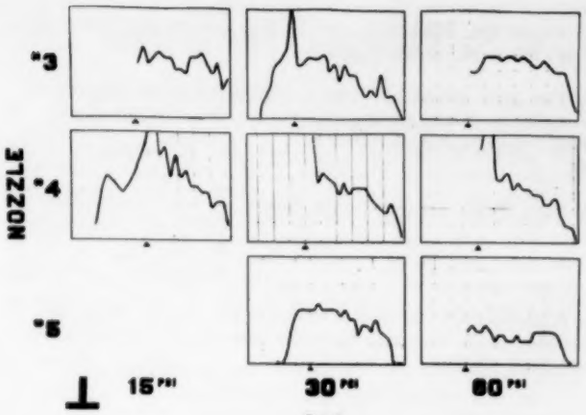


Fig. 8

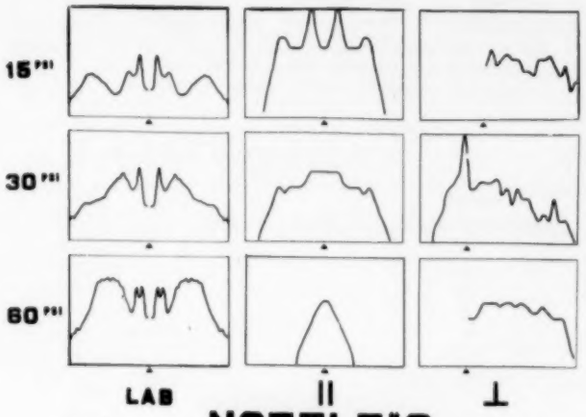
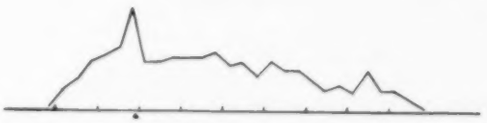


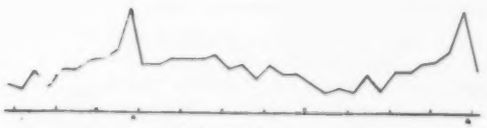
Fig. 9

NOZZLE #3

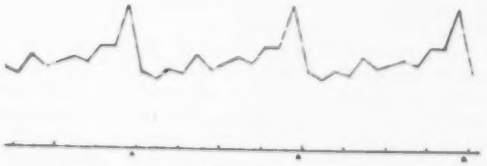
NOZZLE @ 3



SINGLE SWATH



40 ft SWATH

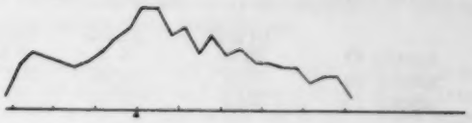


20 ft SWATH

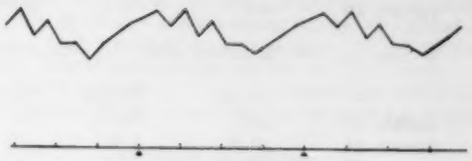
@ = center of swath

Fig. 10

NOZZLE @ 4



SINGLE SWATH



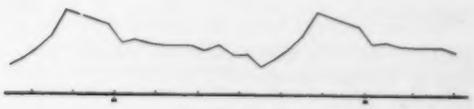
20ft. SWATH

@ = center of swath

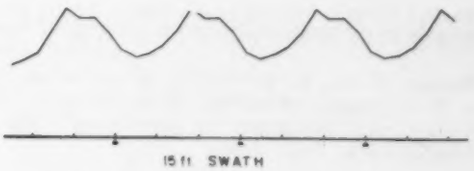
Fig. 11

NOZZLE @ 5

SINGLE SWATH



30 ft. SWATH



15 ft SWATH

@ = center of swath

Fig. 12

Conclusions

From the tests reported in this paper, we might expect the 3 nozzles tested to perform best under the following conditions:

In essentially still air (Beaufort Scale 0-1), with these swath widths:

	15 psi	30 psi	60 psi
nozzle #3	28 ft.	40 ft.	XXX
nozzle #4	XXX	40 ft.	XXX
nozzle #5	XXX	46 ft.	50 ft.

In light breeze (Beaufort scale 2), parallel to the wind with these swath widths:

	15 psi	30 psi	60 psi
nozzle #3	34 ft.	36 ft.	XXX
nozzle #4	XXX	XXX	XXX
nozzle #5	unk.	36 ft.	XXX

In light breeze (Beaufort scale 2), crosswind:

	15 psi	30 psi	60 psi
nozzle #3	unk.	20 ft.	unk.
nozzle #4	20 ft.	unk.	unk.
nozzle #5	unk.	15 ft.	unk.

Summary

In summary, the work reported in this paper shows that there is only a very general relationship between distribution patterns of broadcast nozzles in still air and in light wind, but that reasonably uniform distribution is none-the-less obtainable under some circumstances at a sacrifice of swath width. Laboratory study of broadcast nozzles appears to be of limited value unless they have provision for an artificial wind. These studies also indicate that some further research to determine the characteristics of these nozzles under many field conditions not covered so far would be of value.

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1/ Paper No. 3288 of Scientific Journal Series, Minn. Agr. Exp. Sta., St. Paul, Minn.

2/ The term broadcast nozzle will refer to all nozzles sometimes known as boomless sprayers, and known by such trade names as "Boomjet", "Brodjet", "Brodfan", etc.

3/ Agr. Engr. Res. Branch, USDA 4/ Agr. Engr. Dept., Univ. of Minn. Agric. Exper. Sta., St. Paul Minnesota

5/ Authors express appreciation to Mr. V. J. Johnson and Dr. R. S. Dunham for their assistance in laboratory and field studies.

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WEED CONTROL IN ONIONS WITH CIPC

G. F. Warren 1/

The value of CIPC for control of weeds in onions grown on muck soil has been carefully studied during the past four years. Several experiments have been conducted in which this herbicide was applied at various stages of growth of both weeds and onions. All sprays were applied with tractor-drawn equipment using 25 to 100 gallons of solution per acre and 20 to 50 pounds pressure. Records were obtained on weed control by making counts by species and on onions by taking stand counts and yield of mature bulbs.

The results on weed control showed CIPC to be highly selective giving excellent kill of some species and no control of others. During the course of the experiments it was possible to obtain a large number of records on control of the following weed species: smartweed (Polygonum spp.), purslane (Portulaca oleracea), pigweed (Amaranthus retroflexus), lamb's quarters (Chenopodium album), ragweed (Ambrosia artemisiifolia) and annual grasses. The reaction of these weeds to an 8 pound application of CIPC is summarized in Table 1.

Table 1. Reaction of Weeds to CIPC on Muck Soil (8 pounds per acre)

Weed	Pre-emergence	Early Post-emergence
Smartweed	S	S
Purslane	S	S
Pigweed	R	S
Crasses	R	S
Lamb's quarters	R	V
Ragweed	R	R

S = susceptible R = resistant
V = response variable

It is apparent from the table that more species are controlled soon after emergence than by residual action in the soil. In the case of smartweed and purslane the killing action on emerged weeds is very slow, taking two or three weeks in cold weather. With pigweed and some other species the action is rapid, death of leaves often showing in 24 hours or less. This "contact" killing by CIPC has frequently been overlooked. It should be emphasized however that only small weeds are controlled by this type of action.

The consistent lack of control of ragweed and frequent failures on lamb's quarters have led to the use of combinations of CIPC with other herbicides for pre-emergence treatments. On the muck soils in Indiana most of the lamb's quarters and much of the ragweed emerges before the onions. Mixtures of CIPC with certain contact herbicides have therefore been highly effective. Sodium isopropyl xanthate, ethyl xanthogen disulfide and, where ragweed is not present, Stoddard solvent gave good results in these experiments. Even more successful, however, was the use of 1/4 to 1/2 pound of 2, 4-D amine per acre with 8 pounds of CIPC. In 1954 this treatment, followed by a post-emergence spray of 8 pounds of CIPC when the onions were in the 2 to 3-leaf stage, reduced the hand weeding time for the entire season from 269 man-hours per acre for the check plots to 87 man-hours for the treated plots. All pre-emergence treatments were applied one to two days before onion emergence in order to kill a maximum number of weeds by contact action.

Onions showed no injury from pre-emergence treatments at rates up to 12 pounds of CIPC per acre in experiments conducted under a wide variety of weather conditions. However, an 8 pound rate appeared to be most practical for weed control and would allow a good margin of safety for the onions. Depth of planting did not seem to be critical when CIPC was used alone, but when 2, 4-D was added to the spray it was found important to plant one inch deep and delay the application until one to two days before onion emergence.

Post emergence sprays in the "loop" and 2 to 3-leaf stages caused no injury at 8 pounds and in limited trials at 12 pounds per acre (Table 2). At later growth stages curling of the onions was frequently observed from overall sprays but single applications at this time did not reduce the yield. In one experiment two mid-season sprays did result in a lower yield than the controls and in growers' fields the use of high pressure or repeated applications of this type were sometimes observed to cause considerable damage. The injury seemed to be entirely avoided by using low pressure and directing the spray so that only the lower 1 to 2 inches of the onion plant was hit by the chemical. These mid-season sprays of CIPC were especially effective in the control of purslane which is often so serious in the latter part of the growing season.

Table 2. Tolerance of Onions to CIPC. (12 pounds per acre)

Stage when applied	No. Onions per ft. of row	No. 1 Yield bu/acre
Untreated	8.5	722
Pre-emergence	9.0	856
Loop	8.2	719
2 to 3 leaf	8.3	670
Pre-emergence & 2 - 3 leaf	8.6	721
Loop and 2 - 3 leaf	8.4	702
L.S.D. 5%	N.S.	97

Trials with several commercial formulations of CIPC showed only slight differences in onion injury or weed control. Both Sweet Spanish and various strains of Yellow Globe were used and gave no evidence of marked varietial susceptibility to this herbicide.

The experiments reported here have shown CIPC to be a valuable herbicide for weed control in onions grown on muck soil. The results indicate a combination of CIPC with certain contact weed killers to be especially effective as a pre-emergence application. Early post-emergence and later directed sprays of CIPC alone were effective in controlling many small emerged weeds and gave excellent residual control of purslane and smartweed.

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COMBINATIONS OF CHEMICALS FOR WEED CONTROL IN ONIONS 1/

B. H. Grigsby and S. K. Ries 2/

Pre-emergence applications of a wide variety of herbicides have been made for the control of weeds in onions and the results of these trials have been reported at annual meetings of all the Weed Control Conferences. A listing of these contributions would be far too long for this report but a review of such literature reveals that, while many herbicides are of value for weed control in the onion crop, none of the materials tested have given entirely satisfactory results.

The approximate herbicidal value of a number of compounds has been established but the effects of combinations of herbicides on weed control and onion yields have not been studied. The data reported here were obtained from experiments designed to determine the feasibility of making various combinations of materials which might extend the period of effective weed control beyond the expected time from a single application.

Materials and Methods

Test A: Downing's Yellow Globe onions were planted in April and pre-emergence sprays applied on April 16. The chemicals used were; CIPC, 2, 4-D (ester), Herbisan, and CMU. The rates and combinations used are shown in Table 1.

Test B: A second series of treatments was made on May 19, on a lot of onions planted May 11. In this series CIPC, CMU and Herbisan were applied as pre-emergence treatments and post emergence application on June 28 were arranged so that a combined application of each material with each of the other herbicides was obtained. The rates and combinations used are shown in Table 2. Post-emergence sprays were directed toward the base of the onions so that minimum foliage contact was secured.

The plots consisted of 4 rows spaced 16 inches apart and 25 feet long. The entire area was sprayed and data secured from the two center rows of each plot. Each treatment, or combination, was replicated four times. A randomized block design was used for this factorial experiment.

In Test A, stand counts of onions and weed counts were made on May 29. These data are presented in Table 1. In Test B visual weed control ratings, were made on June 28 and yield records obtained on September 8. These data are shown in Table 2.

Table 1. Onion Stand and Weed Counts after Pre-emergence Application of Herbicides.

Plot	Chemical	Rate lb/A	Onions per 100''	Weeds per sq. ft.
1	none	-	39	93
2	CIPC	4	49	11
3	"	8	45	5
4	2, 4-D (Ester)	.5	53	9
5	2, 4-D + CIPC	.5 + 4	55	7
6	Herbisan	5	30	13
7	"	10	35	8
8	CMU	.5	46	7
9	"	1	32	7
10	CIPC + CMU	4 + .5	37	7
11	" "	4 + 1	42	4
12	Herb. + CMU	5 + .5	37	16
13	" CIPC	5 + 4	43	9
14	T-595	4	35	15
15	"	8	51	17
16	T-596	4	46	12
17	"	8	44	7
18	CMU (FW)	.5	44	5
19	"	1	37	5
20	Aminotriazole	4	54	6
	LSD at 5%			NS 1.87
	LSD at 1%			NS 2.43

Table 2. Effects of Pre- and Post-Emergence Applications of Herbicides on Onion Yields.

Treatment	YIELD, LBS. PER 100 SQ. FT. Pre-emergence	Post-emergence
none	59.4	66.0
4 lb. CIPC	59.6	-
6 lb. "	-	64.4
8 lb. "	61.2	-
12 lb. "	-	60.6
10 lb. Herbisan (Liquid)	60.8	-
10 lb. " (Powder)	-	61.6
1 lb. CMU	61.8	-
2 lb. CMU	-	50.2
LSD at 5%	N.S.	10.0
LSD at 1%	N.S.	13.3

Results

None of the chemicals, at the rates used, had any significant effect on the stand of onions. The stand was poor in the first test because of cold dry weather following planting. Much better stands were obtained in the second trial and no stand reductions due to herbicidal sprays were observed.

All chemicals, alone or in the various combinations, reduced the weed stand 80% or more. The best treatment, 4 lb. CIPC plus 1 lb. CMU gave 95% control of weeds. The least satisfactory materials were T-595, T-596, Carbamate derivatives, and Herbisan, (Xanthogen disulfide).

The data in Table 2 show that the treatments used for pre-emergence applications did not reduce onion yields. Only 2 lb. CMU, as a post emergence spray, caused a significant reduction in yield.

Demonstration spray plots were established on 18 farms at various locations in the state. In these plots, CIPC at 4, 8 and 12 lb., Herbisan at 10 lb., CMU at 1 lb. and 2, 4-D at 1 lb. were used. CIPC was applied at six different stages of onion growth as follows: (1) at

planting; (2) just before emergence,(3) crook,(4) flag, (5) two-leaf,(6) sets with 3-4 leaves.

The following observations were made from the demonstration treatments:

1. 2, 4-D damaged onions that had emerged before the spray was applied and cold dry weather for 10 days after pre-emergence spraying followed by warm rainy weather caused stand losses up to 75% in some areas.

2. CIPC, at rates of 8 and 12 lb. applied in the flag stage or to sets with 3-4 leaves caused injury to the onions. (See Table 3) This may have been due to the solvent in the CIPC formulation.

3. 4 lb. CIPC did not control weeds, 8 lb. CIPC was the best rate for early spring treatments, 12 lb. was necessary for the control of annual weeds in mid-summer.

4. CMU, 1 lb. pre-emergence gave weed control throughout the season. This quantity of CMU at the crook stage caused serious injury to the onions.

Table 3. The Effect of CIPC, Applied When 50 Percent of Onions Were in the Flag Stage, on Onion Stand.

Treatment	Onions per ft. of row
None	11.4
4 lb. CIPC	7.4
8 lb. CIPC	5.5
L.S.D. at 5%	4.1

Discussion

The results obtained in 1954 confirm data obtained with CMU in previous seasons. Generally 1 lb. CMU does not injure onions, but a rate of 2 lb., while more effective in weed control, is likely to affect the growth of onions and to reduce the yield.

CIPC gave good weed control as a pre-emergence treatment and, at a higher rate, was satisfactory for post emergence treatment. However, foliage injury was observed in numerous cases where over-all coverage was used. This injury may have been caused by the solvent used in formulating the CIPC. Best results from post emergence application of CIPC were obtained when the spray was directed toward the base of the onion plants.

The combinations used in these trials generally gave satisfactory weed control. CIPC at 4 lb. with .5 lb. 2, 4-D or CMU controlled weeds as well as twice as much of either compound alone.

Results with 2, 4-D in 1954 were not as satisfactory as had been observed in previous seasons. The severe damage, observed in several areas, was always associated with cold dry weather at the expected emergence time followed by a period of warm weather and considerable rainfall. Such conditions may have led to activation of the 2, 4-D at the time when onion roots were being developed and consequent absorption of lethal quantities of the chemical. The results were similar to those which often follow the application of 2, 4-D Amine.

Summary

1. CIPC at 8 lbs., CMU at 1 lb. and Herbisan at 10 lb. as pre-emergence treatments gave satisfactory weed control without reducing the stand or yield of onions.

2. Yield reductions were caused by 2 lb. CMU applied at the end of June.

3. Combinations of CIPC with CMU and 2, 4-D were equal to twice the amount of either compound at the highest rate used in these trials.

4. 2, 4-D is effective as a pre-emergence herbicide but certain weather conditions may lead to serious injury to the onion crop.

1/ Journal Article No. 1699, Michigan Agricultural Experiment Station

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FIELD STUDIES WITH A NEW CLASS OF HERBICIDAL CHEMICALS

L. H. Hannah 1/

Many workers have reported that annual grasses are becoming a serious problem in most cultivated crops. In fact, last December, a leading academic weed specialist reported that "So far, there has been no new herbicide that will take annual grasses out of corn, and there is not likely to be one soon, since both types of plants belong to the grass family". Even as this statement was being made certain compounds, unknown to him, were already doing this job. Certain amides of chloroacetic acid, including a-chloro-N, N-diallylacetamide and a-chloro-N, N-diethylacetamide show promise as pre-emergence herbicides for the solution of this problem. It now appears that you will be able to eliminate weedy grasses from among certain grass as well as broadleaf crops without injury to the crop. The a-chloroacetamides selectively eliminate various foxtail species, including giant foxtail, crabgrass and certain other annual weedy grasses without damage to cultivated agronomic and horticultural crops.

Test sites were located in the Mid-west, Southeast and Northwest covering a wide spectrum of soils, climatic conditions, crops and weed species. In field trials, involving more than 2700 plots, these new herbicides were compared with most commercially available sales and developmental herbicides. Under certain conditions, which will be described later, a-chloro-N, N-diallylacetamide and a-chloro-N, N-diethylacetamide definitely demonstrated their superiority as pre-emergence grass specific herbicides. This paper will deal primarily with the experimental work conducted in the cornbelt.

Certain a-chloroacetamides were evaluated at four Mid-west locations. The soils representative of the area were silt loam and clay loam type. To insure weed infestation in many of the test plots Italian millet (Setaria italica), and rape were seeded as grass and broadleaf indicators. At all locations, excellent control of the grasses was obtained with the two chloroacetamides, with rates ranging from 3 - 6 pounds per acre. In addition to the grasses, certain broadleaf weeds, such as pigweed and purslane were satisfactorily controlled.

The chloroacetamides, when used as pre-emergence herbicides, gave very satisfactory weed control in horticultural crops, such as sweet corn, onions, carrots, broccoli, spinach, snapbeans, lima beans, turnips, radishes and table beets. a-chloro-N, N-diethylacetamide appeared to be slightly better than the a-chloro-N, N-diallylacetamide in over-all weed control in these crops. In fact, at one location where these compounds were extensively tested, no weed species developed during the entire growing season where a 6-pound-per-acre rate of a-chloro-N, N-diethylacetamide was applied. The two chloroacetamides were also used on a limited basis as residual sprays on asparagus and onions. Weed control was equal or superior to that obtained with already commercially available compounds, without apparent stunting of the crop or reduction of final yields.

In order to determine if the chloroacetamides could selectively control annual grasses in corn, a cooperative field program was set up with a large commercial seed corn grower. One-acre plots in seven different areas were involved. All plots were infested with giant foxtail (Setaria faberii), green foxtail (Setaria viridis), and yellow foxtail (Setaria lutescens). Band treatments 13" wide made with an over-all rate of 6 pounds per acre of a-chloro-N, N-diallylacetamide, resulted in excellent control of all three grass species and reduced the stand and vigor of certain broadleaved weeds. The broadleaf infestation was primarily pigweed.

Crop injury was also nearly lacking where the a-chloroacetamides were applied. When used at a 12-pound-per-acre rate, which is twice the rate necessary for satisfactory weed control, the two chloroacetamides caused no visible crop injury or reduction in yield of the major cultivated agronomic and horticultural crops -- cucurbits being the exception. In addition to these crops, flax, peanuts and cotton were not injured. Slight injury was noted in alfalfa, ladino clover, red clover and birdsfoot trefoil when pre-emergence and post-emergence applications were made.

The a-chloroacetamides are highly effective, even though pre-emergence applications are made on soils low in moisture -- perhaps because of the relatively high water solubility of the compounds. For example, only 0.8 of an inch of rain fell during the 18 days prior to applying the chemicals in a soybean experiment in the Mid-west. Only 0.26 of an inch fell during the two-week period following application, after which 1 1/2 inches fell during a 24-hour period. Five weeks after application, the a-chloro-N, N-diethylacetamide at 4 pounds per acre resulted in 90% grass control, while a-chloro-N, N-diallylacetamide at the same rate gave 93% grass control. In this same experiment, 8 pounds of chloro-IPC were needed for comparable grass control. This rate of chloro-IPC treatment resulted in reduced crop vigor. Even at 12 pounds per acre, the a-chloroacetamides did not reduce vigor or crop stand.

Rain, soon after application of these chloroacetamide herbicides, has not reduced weed control or been detrimental to the vigor of the crop. In another soybean experiment in the Mid-west, 1/2 inch of rain fell immediately after application of the herbicide. Weed control with both chloroacetamides at the 3-pound rate was exceptionally good. In this experiment there was no crop injury, even at the high rate of 9 pounds per acre. One might expect water soluble chemicals to be readily leached, but this has not been the case with these compounds on the heavy soils. Laboratory data show that the chloroacetamides are adsorbed by the organic matter and/or clay in the soil, but nor reversibly. Apparently, quick absorption at the surface layer prevents significant leaching of the chemicals into the crop root zone. It appears that organic matter may play an important favorable role in successful weed control with these new herbicides, since it was found that as the organic matter content increased in sandy soils of the Southeast, weed control treatments lasted longer.

With reference to soil residue, our chemists have indicated that the breakdown of the a-chloroacetamides in the soil can occur by hydrolysis at the a-chlorine atom and/or the amide linkage. The following reactions can occur separately or concurrently in the soil:

$$R_2N - \overset{O}{\overset{\|}{C}} - CH_2CL \rightarrow \underset{\text{glycolic acid amides}}{R_2N - \overset{O}{\overset{\|}{C}} - CH_2OH} \rightarrow \underset{\text{Amine}}{R_2NH} + \underset{\text{glycolic acid}}{HO - \overset{O}{\overset{\|}{C}} - CH_2OH}$$

$$\underset{\text{Amine}}{R_2NH} + \underset{\text{chloroacetic acid}}{HOC - CH_2Cl} \qquad \underset{\text{glycolic acid}}{HO - CH - CH_2OH}$$

By either route the reaction products are glycolic acid and amine. As other side reactions the amine may react with chloroacetic or glycolic acid to give amine salts. Breakdown by enzymatic action may proceed similarly or by a totally different route, for which we have no data. These breakdown compounds occur normally in the soil with no lasting ill effects.

Preliminary animal toxicity studies indicate that the a-chloroacetamides should present no serious hazards in the concentrations used for field application. Technical grade materials are slightly toxic if ingested (approximately the same degree as 2, 4-dichlorophenoxyacetic acid). Both may be absorbed through the unbroken skin, with the diallyl compound more readily absorbed than the diethyl. If allowed to remain in contact with the skin, a-chloroacetamides in full strength will cause serious irritation. Areas of contact develop temporary sensitivity to heat and cold. Undiluted material accidentally contacting eye tissues can cause serious damage if not immediately removed.

Oral toxicity studies with rats indicate that the approximate LD_{50} for a-chloro-N, N-diallylacetamide is approximately 700 milligrams per kilogram of body weight. In the case of the a-chloro-N, N-diethylacetamide, the approximate oral LD_{50} for rats is 500 milligrams per kilogram.

In summary, based on extensive field data it appears that the two a-chloroacetamides referred to have the following characteristics:

1. They are highly effective as grass-specific pre-emergence herbicides for use among a wide variety of agronomic and horticultural crops.

2. They cause relatively little crop damage, even when applied at twice the normal rates needed for adequate weed control.

3. They have been extremely successful on heavy clay soils. Unlike most other herbicides, they have also performed well on high organic matter soils.

4. Weed control effectiveness is not greatly modified by variation in moisture prior to or following application.

5. They are highly effective at low rates -- in the range of a broadcast application of 3 to 6 pounds per acre.

6. Applications should not result in serious hazards.

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CHEMICAL WEEDING OF ONIONS

E. K. Alban 1/

The chemical control of weeds in onions has been under study at the Ohio station for the past seven years. The results of the first four years' study were presented at this conference in 1952. At that time it was reported that Stoddard Solvent was the best of the pre-emergence treatments, and that CIPC appeared promising as a post-emergence spray and possibly as a pre-emergence treatment.

During the past two years, the following chemicals have been included in post-emergence and/or lay-by treatments with onions grown on muck soils: Chloro IPC; SES; NP, sodium PCP; sodium TCA; Dalapon; CMU; sodium isopropyl xanthate; ethyl xanthogen disulfide (suspensions and emulsions); Natrin; Sesin; isopropyl N-(3-methylphenyl)-carbamate (USI 516); sec.-Butyl N-(3-chlorophenyl)-carbamate, (USI 517); isopropyl N-(2-methoxy-5-chlorophenyl)-carbamate(USI 518); (3-chlorophenyl)-carbamate (USI 596); and eight additional chemicals under code numbers. Certain combinations of the above chemicals have also been used. All sprays were applied as directed basal sprays with total volume of spray solution varying from 50 to 100 gallons per acre.

Commercial onion growers have recognized for many years that weeds must be controlled, not only during the growing season, but also through the harvest period. Based on this information, all of our studies have been planned so as to achieve commercial weed control, not only in non-chemically treated checks, but also in onion plots which were treated with weed control chemicals. Therefore, our weed control results with onions have had to be evaluated relative to (1) the cost of weed control without chemicals, (2) the cost of weed control with chemicals and supplemental cultivation, and (3) the yield differences between plots treated with chemicals as compared with non-chemical treated plots. During the past two years, some estimates of the cost of hand-weeding treated and non-treated onion plots has been obtained, as well as crop yields. The evaluation of the chemicals included in these studies are based on the three points mentioned above. Purslane, Portulaca oleraceae; annual grasses, Digitaria sp. and Setaria sp.; pigweed or redroot, Amaranthus retroflexus; lambsquarters, Chenopodium alba; and smartweed, Polygonun sp.; were the major weeds encountered with purslane (75%) and grasses (15%) of most importance.

Directed post-emergence sprays: Previous experiments had indicated that sprays of this type should be delayed until onion plants were reasonably well established. In these studies, a height of six inches was used as a fairly reliable indication of onion maturity as related to the time of first spray application.

Chloro IPC at 3.0, 4.0 and 6.0 pounds per acre rates, applied two or three times during the growing season at about fifteen to twenty-day intervals, provided excellent commercial weed control. Yields from Chloro IPC plots were generally lower than yields from hand-weeded checks. Only in one instance, 3.0-pound rate in 1954 series, was there an increased yield over the check plots. Statistically significant reductions in yield in comparing Chloro IPC and check plots were noted in the 1951 and 1952 seasons where 4.0 and 6.0 pound rates were used. The greatest reduction came in the 1952 season where a twenty-two percent reduction in yield was found with the 6.0 pound rate of CIPC. Throughout the four-year study with Chloro IPC, however, the time required to hand-weed the plots has been about twenty to thirty percent compared with the hand-weeded check plots. With the exception of the 6.0-pound rate in the 1952 season, a comparison of cost of weeding with reduction of yield, indicate that the net return per acre was greater following the use of CIPC. The 3.0 and 4.0-pound rates of CIPC would seem to offer a good calculated risk for the grower in delayed post-emergence use of this chemical.

Combinations of CIPC and sodium TCA or sodium isopropyl xanthate did not provide significantly better weed control and resulted in reduced onion yields.

USI chemicals No. 515, 595, and 596 and two coded chemicals from the Monsanto Chemical Co. at 3.0 and 4.0-pound rates provided excellent weed control in the 1954 season with no apparent injury to onions. Further research with these chemicals is required but in many respects they seemed very satisfactory. Ethyl xanthogen disulfide, in suspension, at 10 pounds per acre offered a reasonably safe chemical weed control treatment for about ten to fourteen days, if the chemical was applied when weeds were small. Potassium cyanate at 16.0-pound rate provided excellent weed control in the 1954 season, but this chemical has not given consistent results through the years and probably has a minimum value for onions in Ohio.

None of the other chemicals included in these studies provided significant commercial weed control or else yields were significantly reduced. This is not to indicate that all of the other chemicals included in these studies are of no value but rather to report that as ordinarily recommended these chemicals did not provide satisfactory commercial weed control under the conditions of our studies.

Lay-by Treatments: Just prior to the period when onion tops begin to fall over there has been a definite need for a chemical spray which will minimize weed growth so that onion harvest can proceed without the hazard of excessive weed cover. Adequate weed control during the harvest period obviously is influenced by the kind of weed control that has been maintained through the growing season. In our studies CIPC, 6.0 to 8.0 pounds; CMU, 2.0 pounds; USI 595 and 596 6.0 pounds; ethyl xanthogen disulfide, emulsion, 5.0 pounds; and 24.0 pounds of sodium pentachlorophenate per acre, have provided excellent commercial weed control when applied as lay-by treatments.

There are many factors which influence the degree of weed control and also the yields of onions as related to the use of herbicides. Some of the major aspects as noted in our studies would include: stage of decomposition of the muck as related to organic content and water-holding capacity; temperature and moisture as they influence the physiological condition of the onion; care used in spraying weeds and soil as contrasted with spraying onions; the weed species to be controlled and the time of spraying these weeds; the timing of hand-weeding and removal of weeds as related to time of spraying; the damage associated with "tillivator" or comparable tillage equipment compared with chemical weed control measures; onion varietal differences, not of too much significance in our studies; and more specific information on when to spray, rate to use, and occasionally what to spray to achieve the best results.

Residual hazards of CIPC and CMU have not been adequately worked out as far as normal rotations of vegetable crops following onions and possible effects of CIPC and CMU residual for a continuous onion cropping program. Weeds can be controlled in onion plantings today with certain chemicals, without significant reductions in yields or quality, but neither the grower nor the research worker can ignore the challenge of the many unanswered questions associated with this new development.

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WEED CONTROL IN POTATOES BY PRE-EMERGENCE SPRAYS 1/

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Weed control in potatoes, as was pointed out by Alban and Comin at the National Weed Control Conference in 1953, generally is accomplished by tillage methods. There is, however, considerable interest among potato growers in the use of chemicals for weed control in this crop. Problems related to soil compaction, irrigation and fertilization practices have brought about an increase in this interest.

The advent of chemicals which may have a relatively long period of herbicidal activity in the soil, yet still permit growth of potatoes, offers the possibility of growing potatoes without the added cost of cultivation and to have the fields weed-free at harvest time. The experiments reported here were designed to determine the feasibility of producing a crop with only three major operations, planting, spraying, and harvesting, and to determine the response of some varieties of potatoes to those herbicides which appear to be best adapted to use in potato production.

Materials and Methods

Potatoes of the Sebago variety were planted on muck soil and pre-emergence sprays of CMU-W, 3(P-Chlorophenyl) 1, 1 dimethyl urea; DW, 3(3, 4-dichlorophenyl) 1, 1 dimethyl urea; and FW, 3-phenyl-1, 1 dimethyl urea were applied at rates of 1 and 2 lb/A. SES, Natrin, and Sessin at 6 lb/A were included in these tests. Plots consisted of 4 rows, 28 inches apart and 50 ft. long. Only the two center rows of each plot were used for record purposes. All treatments were replicated four times in a randomized block design. Sprays were applied when emergence of potatoes was first observed, thus not more than 10 percent of the stand had direct contact with the spray solution.

In another test the varieties Russet Rural, Sebago, and Irish Cobbler were used for a comparison of the effects of 15 herbicides upon the three varieties. These were sprayed as described above, however square rod plots were used.

No cultivation was done in any of the plots but weeds were pulled out of all plots where weed control was not obtained by the pre-emergence sprays. The customary insecticidal and fungicidal applications were made throughout the season.

Results

Weed control ratings and yield records for the test on the Sebago variety are presented in Table 1. The control ratings are averages of observations made four weeks after spraying and at harvest time.

No hand weeding was required for any of the CMU plots but all other treatments were weeded six weeks after spraying.

No significant differences in yield were observed from any treatment.

In Table 2 the weed control ratings and response of three varieties of potatoes to 15 herbicides are shown. Poor weed control was obtained in the TCA, DCU, and Dalapon plots while all other treatments were more effective than cultivation in controlling weeds. Weed populations in the area used were chiefly broad leaved species and are not especially sensitive to TCA and similar herbicides.

Table 1. Yields of potatoes and seasons weed control ratings from pre-emergence treatments.

Plot	Chemical	Rate lb/A	Yield bu/A	Weed Control Rating
1	CMU-W	1	627.2	6
2	"	2	614.1	9
3	CMU DW	1	607.2	6
4	" "	2	640.9	9
5	CMU FW	1	614.4	7
6	" "	2	542.6	9
7	SES	6	674.5	6
8	Natrin	6	620.4	2
9	Sessin	6	641.4	6
10	None		604.4	1
	L.S.D. at 5%		N.S.	
	L.S.D. at 1%		N.S.	

Rating scale 1 = No control, 6 = equal to cultivated field, 9 = No weed growth

Table 2. Weed control ratings and response of three varieties of potatoes to herbicides.

Chemical	Rate lb/A	Weed Rating (1)	Effects on Varieties Russett (2)	Rural	Cobbler	Sebago
1. Silvex (ester)	2	9	7	6		6
2. Silvex (amino)	2	9	7	6		6
3. SES	6	8	9	9		9
4. Sessin	6	8	9	9		9
5. Natrin	6	8	9	9		9
6. Alanap-1	6	8	6	6		7
7. Amizol	1	6	4*	4*		4*
8. 2,4,5-T ester	2	9	5	5		5
9. 2,4-D ester	2	9	6	6		6
10. TCA	10	2	9	9		9
11. DCU	10	2	9	9		9
12. Dalapon	10	2	9	9		9
13. CIPC	8	9	2	2		2
14. Herbisan	10	8	9	9		9
15. DNBP	6	9	9	9		9

Rating scale (1) 1 = no control, 6 = equal to cultivation, 9 = no weeds
(2) 1 = tops killed, 6 = severe curling, 9 = no injury
* Recovered by end of season

Discussion

The results obtained with CMU in these studies are in agreement with other data secured with this compound. The effects from the use of the DW formulation are essentially the same as those from the W plots.

An important effect of the FW formulation was a delay in flowering and a smaller number of flowers in plots treated with FW. This effect probably is related to the setting of tubers and could be of critical importance in certain late maturing varieties. A slightly lower yield was found in these plots but in the statistical analysis an "F" test showed that this was not a significant decrease.

Leaf roll was produced by SES and Sessin but this effect was of short duration and did not have any important effects upon potato yield. Natrin did not cause any noticeable foliage effects. Neither of these three compounds gave effective weed control for more than four weeks and hand weeding was required to prevent excessive weed competition and the possibility of yield reduction.

In the variety trials no outstanding differences between the Sebago, Cobbler and Russett Rural varieties were observed. Russett Rural appeared to be slightly less affected by 2,4-D and related compounds. Amizol and CIPC caused severe damage to all varieties and are not suitable for use in this crop. Alanap likewise caused more damage than can be tolerated in producing potatoes. Of the herbicides tested, only TCA, DCU, and Dalapon failed to give weed control equal to that which can be expected from cultivation. The poor results obtained with these compounds is attributed to the type of weeds present in the area.

Summary

1. Three formulations of CMU, at rates of 1 and 2 lbs. per acre, gave control of all weeds for the entire growing season.

2. Yields of potatoes were not reduced by the CMU treatments.

3. SES, Sessin, and Natrin gave weed control for approximately four weeks and did not reduce the yield of potatoes.

4. The three varieties tested did not show any important differences in response to 15 herbicides.

5. CIPC, Alanap and Amizol caused severe injury to all potato varieties.

1/ Journal Article No. 1700, Michigan Agricultural Experiment Station

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WEEDING ASPARAGUS WITH CHEMICALS

E. K. Alban 1/

The problem of adequate weed control in the production of asparagus has been of major concern for many years. With the increased consumer demand for this vegetable, along with higher costs of weeding, there has been more and more interest in possible improved methods of weed control.

Research with this problem, at the Ohio Agricultural Experiment Station, started in 1942 with calcium cyanamide and continued through the 1954 season, has included over thirty chemicals or combinations of chemicals. Throughout these studies, the asparagus plant has revealed a fairly high degree of tolerance to soil applications at weed-killing rates of most of the available herbicides. The foliage of the asparagus plant during the cutting season and in the post-harvest growing season has revealed a minimum tolerance to most of the herbicides used in these studies. Most of these experiments have been conducted on silty-clay loam soils with age of plantings ranging from two to fifteen years. Certain additional information has been obtained from Ohio growers using these chemicals on muck and sandy loam plantings.

Successful use of chemicals in weeding asparagus involves some of the following considerations:

(1) Spring discing prior to cutting, and discing after the close of the cutting season, must still be considered as essential for good weed control.

(2) Cultivation between the rows during the cutting season and also in the early post-harvest season (determined by tractor clearance) may be helpful in reducing the total cost of weeding.

(3) Weed species present determine the kind, amount, and frequency of chemical sprays.

(4) Weather conditions, prior to and at time of spraying, must be considered as related to kind, amount and frequency of chemicals used.

(5) There is no single chemical which will solve all weed problems in all asparagus plantings. Continuous use of a single chemical through the season and year after year may result in a build-up of resistant weed species. With certain chemicals, such as 2,4-D and sodium TCA, excessive damage to asparagus may follow repeat applic-

ations of these chemicals in the same season.

(6) Band applications over the rows, (18 to 30 inches), along with mechanical control of weeds between the rows, may be worth while, particularly with some of the more expensive chemical treatments. In general, it would seem best to use overall sprays (soil surface) rather than take cultivation equipment into the field, except for discing.

(7) Occasionally, when certain noxious weeds, such as quack grass or Canada thistle start in an asparagus planting, it would seem desirable to eradicate these weeds with a chemical, even though asparagus plants might be severely damaged or killed.

In our studies, it has been noted that there are four general periods in the seasonal management of asparagus plantings that need to be considered for optimum use of certain herbicides. These include the following:

(a) following spring discing and just prior to asparagus emergence.

(b) during the cutting season.

(c) following the post-harvest discing, but prior to emergence of asparagus.

(d) following emergence of asparagus in the post-harvest season and after foliage is approximately 24 to 30 inches high.

After twelve years of study, it is our belief that with present-day herbicides, the least desirable time to control weeds is during the cutting season (b) above. Application periods, (a), (c), and (d) above, offer the best opportunity for successful use of herbicides and if we utilize these periods in proper application of the best herbicide, there will be a minimum need for chemical weed control spraying during the critical and difficult period of harvest.

The following remarks are based on our interpretation of research data and observations on the use of various herbicides in the four periods as previously defined. All rates given are based on complete coverage for one acre.

Chemical Weeding of Asparagus in the Pre-Harvest Period After Discing:

1.0 to 1.5 pounds of the low volatile esters of 2,4-D provided good to excellent control of annual broadleaf weeds and often proved helpful in retarding certain broadleaf perennial weeds.

5.0 pounds of chloro IPC provided good to excellent control of many annual broadleaf weeds and grasses. Particularly good control of chickweed and smartweed.

6.0 to 8.0 pounds of alkanolamine salts of dinitrophenol.

3.0 to 4.0 pounds of 2,4-dichlorophenoxyethyl sulfate.

In the Cutting Season:

Emergency treatments - not generally recommended: Use only after close cutting, since spears above ground may be damaged.

3.0 to 4.0 pounds of alkanolamine salts of DNBP, if not used before.

6.0 to 8.0 pounds of pentachlorophenol.

16.0 pounds of sodium isopropyl xanthate and 6.0 pounds of sodium TCA or 3.0 pounds Dalapon.

20.0 pounds of sodium pentachlorophenate.

Post-cutting, pre-emergence:

1.0 to 1.5 pounds of low volatile esters of 2,4-D, if not used before, and 6.0 pounds of sodium TCA or 3.0 pounds of Dalapon.

6.0 pounds of chloro IPC.

4.0 to 6.0 pounds of alkanolamine salts of DNBP, if not used in cutting season.

3.0 to 4.0 pounds of SES or Natrin.

5.0 pounds of NP.

Post-Harvest, Directed Post-Emergence Basal Applications:

6.0 pounds CIPC and 16.0 pounds of sodium isopropyl xanthate
20.0 pounds of sodium PCP
1.0 pound amine salt of 2,4-D and 6.0 pounds of sodium TCA or 3.0 pounds Dalapon
6.0 pounds of CIPC and 16.0 pounds of sodium PCP

There are many chemicals and combinations of chemicals which can be used in weeding asparagus in addition to those listed above. However, the list above represents the best of the group that we have studied relative to satisfactory weed control, minimum residual hazard, and general usefulness throughout the season.

Chloro IPC, Dalapon, and sodium TCA offer good commercial control of most of the common annual grasses. Chloro IPC offers good control of chickweed and smartweed. Sodium isopropyl xanthate offers good contact control of many broadleaf weeds with no residual hazard. Sodium pentachlorophenate, pentachlorophenol and DNBP provide good chemical mowing of many common weeds, with some residual weed control value. SES, NP, Natrin, and LV ester of 2,4-D can provide excellent control of germinating weed seedlings. The LV ester of 2,4-D can be used for control of many of the broadleaf perennial weeds that are found in asparagus plantings.

The chemical weed control properties of the above chemicals allows for sufficient manipulation so that there would be a minimum need for using the same chemical more than once or twice in a given season. Ideally, no single chemical or closely associated chemical should be used more than once in any given season. Eventually, of course, the ultimate goal should be that the grower reach the point where only one or two chemical applications would be necessary to supplement the mechanical control of weeds.

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POST EMERGENCE APPLICATION OF HERBICIDES ON TOMATOES 1/

S. K. Ries and B. H. Grigsby 2/

In some of the first work on post-emergence application of herbicides to transplanted tomatoes, Ries and Sweet (3) concluded from one year's results at one location that of the chemicals tested, 2 to 4 pounds of Sesin, or 2 pounds of 6036 applied either 4 or 7 weeks after transplanting caused no measurable reduction in yield. However, 2 applications of both of these chemicals did cause a decrease in yield. Crag Herbicide 1 caused a reduction in yield at both the 2 and 4 pound rates. Menges and Aldrich (1) reported that Natrin and Crag Herbicide treatments from 1 to 4 pounds per acre did not reduce yields. Both of these treatments were better than the Benzoate (Sesin) or Oxalate (6036) treatments. One pound of CMU caused a reduction in yield; however, 1/4 and 1/2 pounds of CMU did not decrease yields. Noll and Odland (2) reported a reduction in yield from 4 pounds of Sesin and visible injury from 6 pounds of Natrin.

This experiment was designed to determine the following: 1) which chemical and rate was best for weed control without injury to the tomatoes; 2) which time was best for application, and 3) if two varieties would respond the same to the chemical treatments.

Materials and Methods

The herbicides under test were: Natrin (Na 2, 4-5 trichlorophenoxyethyl sulfate), Sesin (2, 4 dichlorophenoxyethyl benzoate), CMU-W (3, p-chlorophenyl-1-1 dimethyl urea), and CMU-DW (3 (3, 4 dichlorophenyl)1, 1 dimethyl urea).

A split plot factorial design with 2 replications was utilized. The largest division was for tomato variety. The smaller divisions were for chemicals, rates and time.

The varieties Rutgers and Long Red were transplanted May 25 on a sandy loam soil. The plants were spaced at 3 foot intervals in rows 6 feet apart. There were 7 plants per plot and six of these plants were used for record.

A small plot sprayer (4) was used to apply the chemicals in the equivalent of 38 gallons of water per acre directly over the row.

The treatments classified as at transplanting time were applied on May 29, one day after the tomatoes received 1/2 inch of water from an overhead irrigation system. At this time, the tomatoes had 4-6 true leaves. On June 24 the plots to be treated at fruit set were hoed and cultivated prior to the application of chemicals. At this time, the first fruit cluster was set and the plants were in full blossom.

Results

Both of the varieties tested, Rutgers and Long Red, responded similarly to the treatments.

A summary of the means from the analysis of variance for tomato yields and weed control is presented in Table 1. Sesin at 2 and 4 pounds at both times of treatment caused a significant reduction in yield. Four pounds of Natrin at transplanting also caused a significant reduction in yields. Yields from the CMU (W), CMU (DW) and the Natrin treatment compared favorably with the check. The most outstanding weed control was with 2 and 4 pounds of Sesin applied at transplanting time, but these treatments caused severe injury to the tomatoes.

Those treatments that did not reduce yields and gave good weed control were: 2 pounds of Natrin at transplanting time, 4 pounds of Natrin at fruit set, 3/4 pound of CMU (W) at fruit set, 1/2 pound CMU (DW) at fruit set, and 3/4 pound of CMU (DW) at transplanting.

Better weed control resulted from applications of Natrin and the higher rates of CMU at fruit set than with Sesin.

Discussion

Two difficulties arise from treatments applied at time of fruit set. First, it is almost impossible to hoe out all of the weeds prior to treatment, and the chemicals which may be safely used at this time are not effective, on established weeds. Secondly, it is very difficult to obtain good ground coverage when the spray is directed from above the plants, as was the case in this experiment.

The severe injury from Sesin shown in this work is in disagreement with the research by Ries and Sweet (3), in which Sesin was the most promising chemical.

TABLE 1. Yield and Weed Control from Post-Emergence Application of Herbicides to Two Varieties of Tomatoes.

Chemical	Rate lb/A	Time of Application	Yield Tons/A	Weed Control Ratings*
None			34.4	2.0
Natrin	2	Transplanting	31.5	6.2
Natrin	2	Fruit Set	33.3	5.8
Natrin	4	Transplanting	16.3	8.5
Natrin	4	Fruit Set	30.0	6.5
Sesin	2	Transplanting	16.9	9.0
Sesin	2	Fruit Set	21.3	4.5
Sesin	4	Transplanting	6.5	8.8
Sesin	4	Fruit Set	7.7	4.2
CMU (W)	1/2	Transplanting	32.3	5.5
CMU (W)	1/2	Fruit Set	31.9	4.0
CMU(W)	3/4	Transplanting	34.4	5.5
CMU (W)	3/4	Fruit Set	33.6	6.2
CMU (DW)	1/2	Transplanting	32.9	3.2
CMU (DW)	1/2	Fruit Set	31.1	6.5
CMU (DW)	3/4	Transplanting	32.6	6.0
L.S.D. at 5%			9.3	2.3
L.S.D. at 1%			12.4	3.0

* Rating Scale: 1 = No Control, 6 = Commercial Control, 9 = Eradication.

The results of this work, plus that of other research reviewed, indicate that Crag Herbicide, Sesin, and 6036 are not adaptable for weed control in tomatoes. At rates which will control weeds, these chemicals have caused severe reduction of tomato yields in one or more cases. Of the analogs of 2, 4 dichlorophenoxyethyl sulfate, only Natrin at rates of 2 to 4 pounds was satisfactory.

Since there were no reductions in yield from the 2 forms of CMU used at rates up to 3/4 pounds, more research must be done under varying environmental conditions to determine the value of these chemicals for control of weeds in tomatoes.

Summary

Under the conditions of this experiment, the following was determined:

1) Sesin was not satisfactory due to injury to the tomato plants.

2) The varieties Rutgers and Long Red responded similarly to all treatments.

3) 2 pounds of Natrin at transplanting and 2 and 4 pounds of Natrin at fruit set gave satisfactory weed control without injury to the tomatoes.

4) Neither CMU (W) nor CMU (DW) caused injury to tomatoes at the times or rates used.

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SOME ENVIRONMENTAL FACTORS WHICH INFLUENCE THE USE OF DNBP WITH SWEET CORN, LIMA AND SNAP BEANS

E. K. Alban 1/

The dinitrophenols have been used in selective chemical weeding of certain vegetable crops for many years. Prior to the post-war boom, in the mid-forties, with the introduction of 2, 4-D and the subsequent flood of herbicides, the dinitro compounds had been used by many commercial vegetable growers. In recent years, with the introduction of the alkanolamine salts of DNBP, there has been increased use of this chemical in weeding vegetable crops.

While the generally favorable results with DNBP are reflected in the increased use of this material, there have been some instances where crop damage has followed supposedly safe recommended usage. In a paper, presented at this conference a year ago by the author, it was suggested that temperature and humidity were factors which influenced crop damage following use of DNBP. Several other investigators have also reported that high temperatures and high humidities tend to favor DNBP crop damage.

During the past two years, in Ohio, we have been studying the use of DNBP with sweet corn, lima and snap beans in an effort to gain more specific information on the conditions which contribute to excessive damage. These studies were confined to delayed pre-emergence, emergence, and directed post-emergence applications of 2.0 to 8.0 rates of DNBP (alkanolamine salts) per acre. The soil types were Miami or Brookston silty clay loam. Rainfall and irrigation data were recorded for each crop. Planting depth of seed for all three crops was approximately one to one and one-half inches. Under the conditions of these studies, it was concluded that leaching damage from DNBP was negligible as related to germinating crop seedling and/or early root damage. Random examination of crop seedlings, comparing treated and untreated plot areas, tended to confirm this conclusion.

Plantings of the three crops were made so as to obtain considerable variation in temperature and humidity conditions and the usual meterological data were recorded, both prior to and after the spray period. Results are briefly summarized under the following headings:

Delayed pre-emergence: Applications of 3.0, 4.0, 6.0, and 8.0 lb/A rates of DNBP with sweet corn, under dry and moist soil conditions and under various average temperature conditions (55° F. to 82° F.) did not result in significant damage to this crop. There was some indication of dwarfing of sweet corn with the 8.0 lb/A rate of DNBP at the higher temperatures. The 3.0 and 4.0 lb/A rates on dry surface soil did not provide very satisfactory weed control, but higher rates on the dry soil and all rates on the moist soil provided excellent weed control.

Applications of 3.0, 4.0, and 6.0 lb/A rates of DNBP with snap and lima beans, under the above mentioned conditions, followed roughly the same results as obtained with sweet corn. Snap beans revealed greater susceptibility to 6.0 lb/A rate, at the higher temperatures, as compared with lima bean.

Emergence: DNBP rates of 2.0, 4.0, and 6.0 lb/A were made with sweet corn plantings with average growing temperatures of 67° F. and 79° F. Soil moisture was adequate under lower temperature range, at time of spraying, but surface soil was very dry under the high temperature conditions. There was no apparent damage to sweet corn with the 2.0 lb/A rate of DNBP under either temperature range. The 4.0 and 6.0 lb/A rate caused no apparent damage, as shown by stand counts or yields, under the low temperature condition. Under the high temperature, low humidity condition, both the 4.0 and 6.0 lb/A rates caused a significant reduction in stand of sweet corn. The 6.0 lb/A rate reduced stands by approximately 80% and the 4.0 lb/A rate about 30%. The plants remaining in these two replicated treated plots, continued

to show some damage (dwarfing, etc.) for about four weeks, even though the plots were irrigated a week after the DNBP sprays had been applied.

The lima and snap beans were not included in any of the emergence spray studies since previous studies had indicated that this was not a good calculated risk.

Directed basal post-emergence: Sweet corn plants, six to eight inches in height were sprayed at the rate of 3.0, 4.0 and 6.0 lb/A, and the equipment used tended to minimize the amount of spray material which would hit the upper and softer tissue of the corn plant. In two instances, average temperatures were below 73° F.; and in another instance, the average temperature was about 82° F. The 6.0 lb/A rate of DNBP resulted in some damage to sweet corn under all three temperature conditions, but was most severe at the higher temperature. There was some slight delay in maturity under the high temperature and the 6.0 lb/A rate, but there was no significant reduction in yield. At the 3.0 and 4.0 lb/A rates, either temperature range did not significantly affect yields. Under the high temperature conditions, there was a definite dwarfing of sweet corn with all three rates of DNBP, but only the 6.0 lb/A resulted in a definite maturity delay.

With lima and snap beans, 3.0 and 4.0 lb/A rates of DNBP, applied as directed basal sprays, did not result in excessive damage to these crops, under any of the temperature conditions encountered. Snap beans were definitely more susceptible to injury, at the higher temperatures, as compared with the lima beans. Under the higher temperature conditions, the 6.0 lb/A rate of DNBP, caused excessive damage to both lima and snap beans, while under the lower temperature conditions, only snap beans seemed to be injured excessively at this rate. In one instance, in spraying both snap and lima beans, on a day with temperatures in the high nineties, and with a very dry surface soil, there seemed to be an excessive amount of fogging, misting, or volatilization damage on trifoliate leaves. This had not been noted in previous trials.

Conclusions

Excessive damage to sweet corn, lima and snap beans, following DNBP applications, was associated with high temperatures at the time of spraying. Relative humidity, at time of spraying, did not appear to be as important in DNBP injury to crops, as previous work had led us to believe. There was definite evidence that the rate/A of DNBP should be reduced as higher temperatures are encountered. Safe rates of DNBP, applied at emergence or directed post-emergence with these crops at 60° F. to 75° F. temperatures, caused considerable injury as sprays were applied under 80° to 95° F. Four-to six-pound rates of DNBP, which could be safely used with the above crops under lower temperatures, needed to be reduced to two or three pounds under the higher temperature conditions. This had to be done, even at the expense of residual herbicide loss with the lower rates.

Delayed pre-emergence rates of 5.0 to 8.0 lb/A of DNBP, which had proven satisfactory under our soil conditions in the lower temperature range, needed to be reduced to 3.0 to 4.0 lb/A under higher temperatures.

Emergence sprays of 4.0 to 6.0 lb/A of DNBP, which are satisfactory for sweet corn, needed to be reduced by fifty percent under high temperatures.

Volatility and fogging damage from use of DNBP, directed post-emergence, under high temperature conditions warrants consideration. Volatility damage, emergence and delayed pre-emergence applications, with the higher rates of DNBP and under high temperature conditions, may offer an explanation for crop injury.

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CONTROL OF QUACK GRASS IN VEGETABLE GARDENS

Orrin C. Turnquist 1/

One of the most troublesome grasses in vegetable garden culture in Minnesota is quack grass (Agropyron repens). The perennial nature of this plant and the ease with which it propagates have made control by cultivation difficult. In 1949 Barrons (1) reported a new chemical known as trichloroacetic acid for controlling quack grass. Further studies indicated normal growth of spring planted crops on land treated the previous fall to control the perennial grasses. (2) In light of these investigations the following studies were conducted to observe the effect of fall applications of TCA for quack grass control in vegetable gardens.

In the fall of 1950 a heavily infested field of quack grass was selected near Gilbert, Minnesota in St. Louis County. The following six treatments were made to square rod plots:

1. Disced before and after sprayed.
2. Disced before sprayed.
3. Disced after sprayed.
4. Not disced but sprayed.
5. Disced but not sprayed.
6. Not disced or sprayed.

One application of 90% formulation of the sodium salt of trichloroacetic acid was made to each sprayed plot at the rate of 32 pounds acid equivalent per acre. The TCA was applied in water at the rate of 40 gallons per acre.

The following May the treated plots were planted to strawberries and potatoes. At the time of planting the quack grass was growing vigorously on both of the unsprayed plots. All the sprayed plots showed a reduction in growth of the grasses. The best control was obtained on plots disced both before and after spraying. In plots disced only once there appeared to be little difference in weed control whether the discing was done before or after TCA application. No detrimental effects were observed in the growth of the crops planted on the sprayed plots.

In view of the results obtained in the previous experiment, a similar study was conducted in 1953 in the same area. After a thorough discing of a quack grass infested area, four plots each consisting of 160 square feet were laid out in October. Applications of TCA(90% sodium salt liquid form) were immediately made at the rates of 38, 76, and 114 pounds, acid equivalent, per acre.

The following spring several varieties of vegetables were planted in long rows extending across the control and the three treated plots. Vegetables planted included sweet corn, onions, beans, peas, cabbage, cauliflower,

broccoli, and tomatoes. No differences were observed on the growth and yields of these vegetables on any of the plots. The quack grass was controlled equally as well with 38 pounds as with 114 pounds. Discing alone on the control plot gave very poor weed control and considerable hand cultivation and weeding was necessary. At the end of the growing season quack grass appeared to be coming in on the plots which had received the lower rates of TCA.

These studies have demonstrated that fall applications of TCA can be used successfully to control quack grass in gardens without seriously affecting the growth and production of vegetable crops grown on the treated areas the following spring.

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CHEMICAL WEED CONTROL IN VINEYARDS 1/

D. D. Hemphill 2/

Weeds within the grape must be removed for maximum grape production. These weeds are usually removed by a grape hoe or by hand cultivation. Cost of hand removal is prohibitive and use of the grape hoe is not entirely satisfactory due to damage to the root system of the grape plant.

An important advance was made by the development of a weed spray consisting of a water emulsion of dinitro fortified aromatic oil (1).

This chemical spray for weeds in the vineyard is widely used at the present but it is not satisfactory in all respects. The trunks of young vines without a protective coating of loose bark, as well as leaves, shoots, fruits and canes are severely injured or killed by contact with the spray. Furthermore, the residual properties of this spray are not adequate. Two or more sprays must be applied each season to keep down weeds through the harvest period.

In an effort to develop a more satisfactory chemical weed control program for grapes, experimental work was initiated in 1951.

Procedure and Results

During the 1951 season SES (sodium 2, 4-dichlorophenoxyethyl sulfate), Endothal (disodium 3, 6-endoxohexahydrophthalate), NIX (sodium isopropyl xanthate) and Sulfasan (ethyl xanthogen disulfide) were compared with dinitro fortified oil emulsion (20 gallons diesel oil : 3 pints DNBP : 80 gallons water). Four 50 ft. one row plots were used as replicates for each treatment. The chemical sprays were applied in a 24-inch band along the plant row. The soil is a heavy silt loam with a heavy clay subsoil.

None of the above chemicals were as effective and none had longer residual properties than the dinitro fortified oil. Endothal and SES were more effective than NIX and Sulfasan.

Studies were continued in 1952 using CMU (3-p-chlorophenyl)-1, 1-dimethyl urea, Endothal, NP(N-1 naphthyl phthalamic acid), SES and dinitro fortified oil emulsion. CMU at the rate of 1 pound per acre of the sprayed area gave fairly effective weed control for most of the season with no detectable injury to the foliage or fruit. Two applications of all other chemicals were necessary even though drought conditions prevailed during the summer months.

During the 1953 season the following treatments were employed: CMU, 2 pounds per acre; phenyldimethyl urea (PDU), 2 pounds per acre; CIPC, 10 pounds per acre; dinitro fortified oil emulsion and control. All chemicals were applied in a 2 ft. band along the plant row. CMU, CIPC and phenyldimethyl urea (PDU) gave excellent weed control for the whole season with little if any evidence of injury. Two applications of dinitro fortified oil emulsion were necessary. Climbing Milkweed (Ampelamus albidus) was the only weed that was found consistently in the treated plots. The primary weeds in the vineyard were crabgrass (Digitaria sanguinalis), foxtail (Setaria spp.), pigweed (Amaranthus retroflexus), and purslane (Portulaca oleracea). The CMU plots were the same plots that were treated with this chemical in 1952. The 1953 season was considered a drought year.

In 1954 the plots received the same treatments as in 1953. Prior to the application of the first weed sprays on May 4th all missing plants in the vineyard were replanted using one year Missouri Riesling stock. Normal rainfall (5.39 inches) prevailed during the month of May but the remainder of the season was extremely dry and hot.

Weed counts were made on June 10. A dense stand of weeds, particularly grasses was present in control and dinitro-oil plots while other plots were relatively free of weeds. Results are shown in the following table:

Treatment	Weeds/Sq. Ft.		Per Cent Control	
	Narrow-leaved	Broad-leaved	Narrow-leaved	Broad-leaved
Control	66	7		
Dinitro-oil	54	4	18.18	42.85
CIPC	0	1/9	100.00	98.42
CMU	2/3	1/3	99.00	95.28
PDU	2/9	2/9	99.66	96.85

Weeds in dinitro-oil plots as well as those in control plots were removed by hand labor before the second application was made to the dinitro-oil plots. CIPC, CMU and PDU plots were not retreated and remained free of weeds for the entire season except for an occasional giant foxtail or climbing milkweed plant.

During the month of June chlorosis was evident in mature vines in the PDU plots and the new transplants became chlorotic and most all died. New transplants in CMU plots exhibited chlorosis but none died. No chlorosis or other injury was detectable on mature vines in these plots. No injury was detectable on mature vines or new transplants in the CIPC plots.

Discussion and Summary

The results of these studies indicate that CIPC and CMU may possibly be superior to dinitro fortified oil emulsion as a weedicide spray for mature grape vineyards. One application tends to give satisfactory weed control for an entire season.

The use of CMU in recently planted vineyards does not appear advisable.

Five pounds of CMU used during a 3-year period has not given any detectable injury; however, the accumulative effects of CMU over a longer period and the effects of this chemical as it leaches to greater depths in the soil are in need of further study.

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1/ Journal Series Paper No. 1498, Missouri Agricultural Experiment Station

2/ University of Missouri, Columbia, Missouri

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WEED CONTROL IN APPLE AND CHERRY ORCHARDS

LeRoy Holm and Franklin A. Gilbert 1/

The control of weeds in tree fruits at the present time is largely by hoeing, mowing, cultivating, or by mulching. Mowing and cultivation are not expensive but they must be repeated often and they do not control the weeds in the areas adjacent to the trees. Mulching and hoeing are the practices in use today for controlling the weeds at the base of the tree. Mulch material is expensive, difficult to acquire, and it must be applied heavily if it is to give lasting weed control. Hoeing is difficult, if not impossible, where weeds are very bad. This practice is so expensive that it is not done often enough.

There have been only a few reports of research with herbicides in orchards. A sincere effort has been made to use oils and oils fortified with contact herbicides such as PCP or Dinitro. Oils are much more difficult to use with safety on deciduous, woody, perennials than most people realize. TCA has been tried in sour cherries in Michigan.

Wisconsin has one of the large sour cherry growing areas of the United States. It is located on the peninsula which extends into Lake Michigan and has a very thin layer of topsoil underlain by limestone. In some orchards this topsoil is less than 12 inches in thickness. The reservoir for holding nutrients and soil moisture is, therefore, extremely small and the trees suffer quickly when weeds compete with them for these essential factors. We have had some success in controlling these weeds with chemicals.

During the past four years most of the new herbicides have been tested but the greater portion of our work has been with CIPC, Endothal, and CMU both alone and in mixtures. Where treatments were made at only one date, this was done in April following a clean-up of the area by mechanical means. Areas which were sprayed a second time with the same chemical were treated in mid-July. The herbicides were applied at 30 psi in 40 gallons of water per acre from a boom mounted on bicycle wheels. A four-foot strip was sprayed on each side of the row of trees. Twelve to fifteen inches of the base of the tree were covered with spray during the treatments. Both broadleaved weeds and grasses, including large amounts of quack grass, were present in the area.

From Table I it may be seen that a single treatment with a mixture of CMU with CIPC, or of CMU with Endothal, provided 90 to 95 percent weed control for the season. Two applications of CMU or of CIPC proved to be slightly more effective.

Table I. Weed Control in Sour Cherries

Treatment (Pounds per acre)	Weight of weeds per plot (August)	Percent of Weed growth eliminated
Control unweeded	13.70	0
CMU 2.5 Then 2.5*	0	100
CIPC 20 Then 10*	.95	93
CMU 2 Plus CIPC 10**	1.35	90
CMU 2 Plus Endothal 10**	.60	96

* Chemical applied in April and again in July.
** A mixture of 2 chemicals applied in April only.

In Table II it may be seen that none of the chemicals have interfered with the growth of the trees. These 4 year old trees were treated for the first time in 1954. It is planned that this block will receive these treatments annually henceforth in order that we may see whether a cumulative toxicity will build up under continuous treatment. I may say that we have never seen injury from Endothal or CIPC applied in four successive years to the same trees. We have never seen it with CMU at the rates I have shown you here. Experimentally, we have been able to show slight leaf discoloration very late in the season on trees which have received 5 pounds of CMU per acre per year for three years. This discoloration is more severe where the 10 pound rate was used. Each spring these trees leaf out normally, make as much growth as our controls, and are the best trees in the block during the season.

Table II. Terminal Growth of Four Year Old Sour Cherry Trees

Treatment* (Pounds per acre)	Average growth of individual terminals (October)
Control weeded	18.15 inches
CMU 2.5	19.13 inches
CIPC 20	19.03 inches
Endothal 20	19.28 inches

*Chemicals applied April 15.

We began working with apples in the spring of 1954. Table III shows the weed control in the Delicious and McIntosh apple blocks in mid-October. There has been no injury to any of the trees from these treatments. The control of weeds appears to be somewhat less effective than was the case under cherries. This is so because the area was in a mixed legume stand during the preceding season and a few large volunteer legumes survived the treatment and were included in our weight measurements. Actually, legumes have been much more difficult to kill than the weeds of the area during our four years of experimentation on this problem.

Table III. Weed Control in Apples

Treatment (Pounds per acre)		Weight of weeds per plot (October)	Percent of weed growth eliminated
Control unweeded		19.9	0
CMU	2.5	6.5	67
CIPC	50	6.3	68
CMU	2.5	3.5	83
" plus CIPC	20		

As is frequently the case, our success with herbicides at the base of the tree led us into another, quite different, series of investigations. I believe most of you are aware that injury to tree trunks from mice and other rodents is a serious problem. These rodents will usually not bother a tree if the trash and old vegetation are hoed and pulled back a short distance from the tree. They must have cover under which to travel and feed.

We have been able to use CMU and mixtures of CMU and CIPC in the spring to kill all vegetation in a small circle around 6 and 30 year old apple trees. In the fall the rotted trash is then easily pulled away from the trunks with a rake. CMU at 10 pounds per acre has not injured 6 year old Whitney Crabs after one growing season. Two treatments of 12 pounds per acre of CMU since April of 1953 have not injured 30 year old Wealthy trees. This treatment would be very inexpensive since only an area about 10 feet in diameter is covered with the herbicide. It appears also that treatments may last at least two years for this purpose.

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CHEMICAL WEED CONTROL IN TAXUS

L. C. Chadwick and P. A. Barker 1/

Introduction

An important cultural practice in nursery management is the suppression of weeds, largely accomplished in the past through crop rotation, mulching, hand hoeing, and cultivation. With the advent of the many new and promising herbicides, attention has been focused on chemical weed control. Providing herbicides do not cause crop injury, a promising method of weed restriction and control is to apply the chemical over the plants and onto the soil prior to weed emergence.

This paper describes herbicide experiments conducted at Ohio State University during the summer of 1954 in a nursery field containing 4-year plants of Taxus cuspidata intermedia. The principal objectives of the study were to determine: (1) the tolerance of Taxus cuspidata intermedia to certain herbicides applied as post-emergence sprays prior to weed emergence and (2) the weed control obtained when certain herbicides were used.

Review of Literature

Linder (2) found that the greatest degree of weed control with sodium 2, 4-dichlorophenoxyethyl sulfate (SES) was obtained when it was applied to the soil where it could be taken up by the roots, rather than when applied to the leaves or stems. He also reported that maleic hydrazide (MH 40) and isopropyl-N-(3-chlorophenyl) carbamate (CIPC) caused a retardation of growth when applied to the soil. DeRose (1) reported concentrations of CIPC "possess the property of preventing crabgrass germination or inhibited growth of established seedlings."

Materials and Methods

The herbicides tested were: amine salt of 2, 4-dichlorophenoxyacetic acid (2, 4-D), N-1-naphthyl phthalamic acid (NP), CIPC, MH 40, SES, and sodium isopropyl xanthate ("NIX"). Applications were made at rates of 1, 5, 7.5, 20, 3 & 4, and 12 & 24 lb/A, respectively. The treatments, made on Brookston silt loam soil, included those of Series A, applied on June 1 and 4; Series B, applied on July 10; and Series C, applied on September 1, 3 and 4. The same plots were used for each series of treatments. Plots 2, 8, and 13 were treated with NP, plots 3, 7, and 14 with SES at 3 lb/A, plots 5 and 10 with SES at 4 lb/A, plots 4 and 6 with CIPC, and plots 11 and 12 with 2, 4-D and MH 40 respectively. Check plots were 1, 9, and 15.

Preceeding each series of treatments, plots were clean cultivated by hoeing out the weeds, raking them off, and then cultivating with a tractor. As far as was practical, treatments were made when the soil contained a good amount of surface moisture. Throughout the summer there was a normal amount of rainfall with 3.27 inches in June, 3.57 inches in July, and 4.87 inches in August. At times in July and August however, the soil became very dry because of the unusually high daytime temperatures.

Between Series A and Series B, all the plots were sprayed with either 2, 4-D or contact herbicides in an attempt to eliminate those weeds that were not controlled by the series treatments. On July 29, 1 and 1.5 lb/A of 2, 4-D was sprayed on plots 8, 9, and 10 where field bindweed had covered the ground. The bindweed had not yet flowered. On August 11 and 12, plot 13 and one-third of plots 2, 3, 4, 5, 6, and 7 were sprayed with "NIX" at 12 or 24 lb/A. On plot 12 and another one-third of plots 2, 3, 4, 5, 6, and 7, CIPC was applied at 7.5 lb/A. The center third of each plot was left as a check area.

Applications of all herbicides were made with a 3-gallon compressed-air type sprayer fitted with a No.

730385 tee-jet fan type nozzle. Water was used at 80 gal/A and when spraying, a pressure of 30 to 40 psi was maintained. In making the applications, the operator walked in line with the nursery rows while the sprayer nozzle was held so that the spray fan was perpendicular to the rows.

Weed control evaluations were made on the basis of: (1) appearance of the foliage and bark of the Taxus plants, and (2) visual comparisons of the weed growth in the various plots.

Results and Discussion

Natural weed populations encountered in the test area included a number of common weeds such as: purslane, Portulaca oleracea; field bindweed, Convolvulus arvensis; lambsquarters, Chenopodium album; redroot pigweed, Amaranthus retroflexus; smartweed, Polygonum pennsylvanicum; prickly lettuce, Lactuca scariola; dandelion, Taraxacum officinale; and Canada thistle, Circium arvense. The prevalence of bindweed and Canada thistle was limited to plots 8 through 15.

Results of Series A: Observations were made on June 30, about four weeks after application. Purslane was the predominant weed in Plots 1 through 8. Field bindweed was predominant in plots 9 and 10, and Canada thistle predominated in plots 11 through 15. The latter two weeds were not controlled with any herbicide. Compared with check areas, the stems of Canada thistle where sprayed with NP, were long and slender and the leaves pointed upward. SES caused some reduction in growth and distortion of the leaves of field bindweed. Purslane was controlled most effectively with NP.

Considering the total weed population, NP and SES at 4 lbs/A provided 90 and 70 percent weed control respectively. CIPC and SES at 3 lb/A reduced weed growth about 50 percent when compared with the check plots. Pigweed was quite prevalent in the CIPC plots. Neither 2, 4-D nor MH 40 provided satisfactory weed control on any of the weed species.

Results of Series B: As in Series A, none of the herbicides tested seemed to provide any effective control measure against the bindweed and thistle. Plots treated with CIPC were almost entirely free of all weeds with the exception of only a few frail purslane plants. These plots remained relatively clean for as long as seven weeks. NP and both rates of SES controlled purslane less effectively than in Series A. This difference may be explained on the basis that almost all the immediate regrowth of the purslane originated from vegetative cuttings that remained following the hoeing and cultivation and before the chemicals were applied.

Abundant seedlings of newly germinated purslane emerge during the week of July 29, about 3 weeks from the time of treatment, in all the plots except those that had been treated with CIPC. These seedlings were in the two-leaflet stage at the time of this inspection but those growing in the MH 40 plot were about twice the size of those in the other plots. In the NP plots, thistle growth was much greater than in the check areas. Again 2, 4-D and MH 40 provided little weed control.

Weed foliage spraying: Where 2, 4-D had been applied July 29, it eliminated all the aerial portions and much of the root system of the field bindweed. Purslane, however, appeared to be quite resistant to 2, 4-D.

When applied as a non-directed contact spray, CIPC gave good control of purslane, crabgrass, and field bindweed, but not Canada thistle. Weeds were slow in showing the damage due to the CIPC but over a period of two weeks these weeds defoliated and later the stems became desiccated and black in color. "NIX", applied as a directed contact spray, killed all broadleaf weeds within three days following application although the 24 lbs/A rate was more effective. Grasses made rapid growth in those areas treated with "NIX".
Results of Series C: Five weeks from the time of Series C, field bindweed in plots 8, 9, and 10, and Canada thistle in plots 10 through 13 were the only weeds that had made significant regrowth. Where the field bindweed had been killed to the ground by the 2, 4-D foliage treatment that was made on July 29, it had made only spotty regrowth compared with the check areas.

On November 19 bronzing was observed on the tips of several of the Taxus plants that had been sprayed with CIPC and NP. Determinations of any damage will have to be made next year.

Summary

Overall weed control obtained in Series A and Series B was similar. As a result of the foliage application of 2, 4-D, "NIX", and CIPC, average hoeing time per plot for weed cleanup prior to treatments was reduced from 3.73 man hours for Series B to 1.07 man hours for Series C.

From the results of these experiments it may be concluded that, with the possible exception of CIPC and NP, none of the herbicides at the rates tested caused any damage to the Taxus plants. Further tolerance tests will be needed before CIPC or NP are used extensively.

Variations in the extent of weed control for each herbicide was apparent. These will be discussed separately for each herbicide.

2, 4-D: Adequate control was not obtained where 2, 4-D was applied to the soil. When used on the foliage, it killed the aerial portions of field bindweed and Canada thistle but not purslane. With repeated applications, less bindweed and thistle would probably have survived.

NP: In Series A, NP looked very promising for controlling many of the more common weeds except field bindweed and Canada thistle. But in Series B its effectiveness was somewhat reduced. Stimulation of growth occurred on smartweed and Canada thistle and this would suggest that if used at a higher rate, NP might give better weed control.

CIPC: For soil treatment prior to weed emergence, CIPC provided perhaps the best overall control although it was not fully effective in Series A. It also gave good results when used as a contact herbicide on purslane and some other common weeds.

MH 40: Little weed control of any type was obtained with MH 40.

SES: Good control of most weeds was obtained with SES. However, a more through removal of purslane stem cuttings and better surface moisture prior to application would have contributed to greater effectiveness.

"NIX": As a general contact spray to eliminate established weeds, "NIX" was highly satisfactory. Grasses were not controlled.

From the foregoing observations it appears that herbicide treatments can be a useful tool in combating weeds in commercial nurseries. A weed-free nursery might best be obtained by first applying a directed contact herbicide such as 2, 4-D, "NIX", or CIPC, depending on the weeds species. Following such a treatment, the nursery could be kept free of weeds by spraying with such herbicides as SES, CIPC, or NP before new weeds emerge.

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CHEMICAL WEED CONTROL IN DECIDUOUS AND EVERGREEN NURSERY STOCK

L. C. Chadwick and P. A. Barker 1/

Introduction

It has been shown by Shadbolt and Holm (6) that considerable reduction in size of crop plants results when they are grown in competition with other vegetation. With an increasing shortage of seasonal labor that has, in the past, kept the weeds hoed, other methods of controlling nursery weeds are needed. Crop rotation has been found helpful and in recent years, interest has been stimulated in controlling weeds chemically. Nursery crops, unlike wheat or corn, may occupy the land for several years and the many plant species vary greatly in adaptability and hardiness. If a herbicide is to be suitable for weed control in nursery crops, the plants must be tolerant to it regardless of their age, size or species.

Since sodium 2, 4-dichlorophenoxy ethyl sulfate (SES) has met such specifications on a limited scale, further experiments were conducted during the summer of 1954 to determine the tolerance of various plant species to this chemical and to note its effectiveness in weed control.

Literature Review

King and Lambrech (2) reported that SES, when applied to the soil, was a toxicant for germinating weed seeds. They presumed that it was toxic only to germinating seeds and not to dormant seeds. Excellent weed control was maintained for approximately 3 weeks when Finn and King (1) applied SES to the soil and they found further that crabgrass could be controlled best when incipient germination occured over a period of several days before the herbicide was applied. This work was further verified by Linder (3) who suggested that SES was absorbed more readily by the roots than by the leaves or stems. In a 5-year study of SES, Mahlstede and Denisen (4), reported that SES gave good control of weeds in a general line of nursery stock. They reported the most efficient rate of application of SES as 2 to 4 lb/A with the heavier soils requiring the higher rates. Drift hazard, they suggested, was probably negligible.

Materials and Methods

SES was applied as a non-directed post emergence spray before emergence of weeds in field rows and bedded stock at four Ohio nurseries and in perennial flower beds at Ohio State University. Except in the perennial beds, each plot was 1000 sq. ft. and treatments in them was made on July 12, 16, 22, 27, and 30, generally when the silt loam or fine sandy loam soils had good surface moisture. Application of SES, at 4 lb/A throughout, was made with a 3-gallon compressed-air sprayer that was fitted with a No. 730385 tee-jet fan type nozzle. Water was used at 80 gal/A and when spraying, a pressure was maintained between 30 and 40 psi. In making the applications, the operator held the fan of spray perpendicular to the nursery row while he walked in line with the rows.

Natural weed populations encountered in the test areas included such common weeds as: purslane, Portulaca oleracea; field bindweed, Convolvulus arvensis; lamb's quarters, Chenopodium album; redroot pigweed, Amaranthus retroflexus; smartweed, Polygonum pennsylvanicum; and dandelion, Taraxacum officinale.

A total of 120 species of plants were growing in the plots at the time the SES was applied. They are listed below:

DECIDUOUS

1. Acanthopanax sieboldianus
2. Berberis thunbergi atropurpurea
3. Caryopteris incana
4. Cornus florida
5. Cornus mas
6. Cornus mas elegantissima
7. Cotoneaster adpressa
8. Cotoneaster apiculata
9. Crataegus phaenopyrum
10. Euonymus alatus
11. Euonymus alatus compactus
12. Euonymus europaeus
13. Euonymus europaeus, Burton
14. Fontanesia fortunei
15. Hamamelis virginiana
16. Hibiscus syriacus, Woodridge
17. Ligustrum obtusifolium, Vicory
18. Ligustrum obtusifolium regelianum
19. Lonicera korolkowi zabeli
20. Magnolia virginiana
21. Myrica pennsylvanica
22. Philadelphus virginalis
23. Physocarpus opulifolius nanus
24. Salix purpurea nana
25. Spirea coccinea japonica
26. Viburnum burkwoodi
27. Viburnum dentatum
28. Viburnum tomentosum

EVERGREENS, BROAD-LEAVED

1. Euonymus fortunei coloratus
2. Euonymus radicans erectus
3. Euonymus kiautschovicus
4. Euonymus kiautschovicus, Newport
5. Euonymus fortunei radicans
6. Euonymus fortunei vegetus
7. Ilex glabra
8. Mahonia aquifolium.
9. Pyracantha coccinea lalandi
10. Viburnum rhytidophyllum

EVERGREENS, NARROW-LEAVED

1. Juniperus chinensis, Hetz
2. Picea abies
3. Picea glauca
4. Pinus sylvestris
5. Thuja occidentalis, Douglas Pyramidal
6. Thuja occidentalis, Pyramidal Eastern
7. Thuja occidentalis spiralis
8. Taxus cuspidata intermedia

PERENNIAL FLOWERS

1. Achillea spp.
2. Alyssum saxatile
3. Anchusa azurea
4. Anchusa barrelieri
5. Anemone appennia alba
6. Anemone japonica
7. Aquilegia spp.
8. Artemisia albula
9. Asclepias tuberosa
10. Aster, Frikarti
11. Aster novaeangliae
12. Baptisia australis
13. Brunnera macrophylla
14. Campanula persicifolia
15. Caryopteris clandonensis
16. Catananche caerulea
17. Celosia argentea
18. Centaurea dealbata
19. Cerastium tomentosum
20. Clematis recta
21. Coreopsis grandiflora
22. Coreopsis verticillata
23. Dicentra spectabilis
24. Dictamnus albus
25. Dianthus allwoodi
26. Echinacea purpurea
27. Eupatorium coelestinum
28. Filipendula hexapetala
29. Gaillardia aristata
30. Geranium ibericum
31. Geum montanum
32. Halenium tenuifolium
33. Helianthus decapetalus
34. Heliopsis scabra
35. Heuchera sanguinea
36. Hibiscus spp.
37. Hosta lancifolia
38. Iberis sempervirens
39. Iris japonica
40. Iris spp.
41. Liatris scariosa
42. Liatris pycnostachya
43. Linum perenne
44. Lychnis coronaria
45. Lycoris squamigera
46. Lythrum salicaria
47. Macleaya cordata
48. Monarda didyma
49. Nepeta mussini
50. Papaver spp.
51. Penstemon barbatus
52. Phlox spp.
53. Physostegia virginiana
54. Platycodon grandiflorum
55. Polemonium caeruleum
56. Potentilla atrosanguinea
57. Rudbeckia laciniata
58. Rudbeckia specissa
59. Salvia azurea
60. Salvia pratensis
61. Sedum spectabile
62. Stachys lanata
63. Thalictrum aquilegifolium
64. Thalictrum glaucum
65. Thalictrum minus
66. Thermopsis caroliniana
67. Tritoma, varieties
68. Tritoma, White Giant
69. Veronica incana
70. Veronica longifolia subsessilis
71. Veronica spicata
72. Viola adorata
73. Zinnia varieties

Weed control was tabulated where it seemed to be significant, although in many test areas, weeds were not a serious problem. Lack of weeds was due possibly to the unusually high July and August temperatures that kept the soil quite dry. Many of these areas had been well managed also and the weeds were kept hoed during the early part of the season.

Results and Discussion

Observations were made within 30 days following treatment and periodically thereafter through October, 1954. Evaluations were made on the basis of the appearance of the foliage, bark, and roots and visual comparisons of the weed growth in the various plots.

No injury was noted on any of the evergreen species or any of the perennial flowers. Adequate weed control was obtained in the perennial beds although established purslane and crabgrass grew vigorously until a contact spray of sodium isopropyl xanthate ("NIX") was applied. Weed control was variable in most other plots but there was definite reduction in field bindweed, lambs quarters, and crabgrass in a bottomland area of one nursery where plots were being grown to transplant size.

Some injury, evidentally due to SES, did appear on some of the deciduous plant species; however, it was spotty and not consistent throughout the test plots. There was swelling at the groundline on the stems of Ligustrum obtusifolium regelianum and a slight reduction in plant size.

The bark on the underground portion of the stems of Euonymus klautschovicus split and became necrotic and shaggy throughout.

Splitting was common on the underground portion of the stems of Euonymus fortunei coloratus, out of which grew fleshy rootlets. Instead of the usual bleached green color, the underground bark was yellow and brown. An abundance of fleshy rootlets developed from the normally branched fibrous roots.

About one to two inches of bark on Euonymus alatus compactus, from the ground line down to the root region, pulled away from the wood and later sloughed off. Heavy callus was proliferated from the exposed cambium tissue and the leaves turned prematurely purple. This condition might have been instigated by cultivator damage but it was more noticeable in the treated plots.

Summary

In testing the tolerance of nursery plants to SES, 120 plant species were sprayed with this chemical at 4 lb/A. No toxic effects were noticed on any plants except Ligustrum obtusifolium regelianum, Euonymus klautschovicus, Euonymus fortunei coloratus, and Euonymus alatus compactus. Weed control results were variable due possibly to the high summer temperatures and also to the fact that many of the areas were well managed and weeds were kept under control during the early part of the season.

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SOME EFFECTS OF ALANAP (NP) AND AMIZOL ON GERMINATING PEAS 1/

B. H. Grigsby, Te May Tsou and G. B. Wilson 2/

The herbicide NP (N-1, naphthyl phthalamic acid) has been reported by Hemphill (1) and L'arrivee and Andersen (2) to have no effect on the emergence, growth and yield of peas; however, detrimental effects have been reported by Mentzer and Netien (3) and Netien and Canillot (4). Field tests of this compound at East Lansing have shown that the growth of a number of vegetable crop plants is adversely affected by small amounts of the chemical.

At the present time there are few recorded observations of the effects of 3-amino 1, 2, 4-triazole (Amizol) upon the early growth and development of crop plants. Field observations, however, have shown that severe disturbance of plant development may follow the application of small amounts of this compound.

In order to obtain some indication of the nature of the disturbances caused by Alanap and Amizol, a number of laboratory experiments were carried out during 1954.

Methods

The Pisum test, as described by Bowen and Wilson (5), was used as a means of studying the effects of the two herbicides on pea seedlings. Essentially, this test consists of exposing the roots of young seedlings, three to four centimeters in length, to the test chemicals dissolved or suspended in a standard nutrient solution. Samples for cytological examination were taken at designated intervals during the course of the treatment and a subsequent recovery period. Seeds of Pisum sativum, var. Alaska, were used for all tests in these experiments.

NP-1 with a solubility of less than 100 ppm. was used as a suspension in amounts equivalent to 100 and 1000 ppm. A highly soluble form, NP-III, was used as a solution at concentrations of 100 and 1000 ppm.

Amizol (fifty percent amino triazole and fifty percent wetting agent) was used at apparent concentrations of 200, 1000 and 2000 ppm.

The pea seedlings were kept in the test solutions for twenty-four hours, washed, and placed in nutrient solution for a seven to fourteen day recovery period.

Results

Data concerning the growth of treated pea seedlings are presented in Table 1. Both forms of NP reduced root and shoot growth as well as caused considerable curling, especially in the roots. Also the portion of the root between the meristem and the surface of the test solution developed a characteristically purple color.

During the recovery period, some growth occurred and both roots and shoots elongated in the direction in which they were pointed at the end of treatment. Normal geotropic polarity was never resumed during the recovery period.

Secondary roots first emerged from the region above the point of immersion in the test solution and later from the region of new growth of the tap root. These new roots also exhibited a lack of polarity.

TABLE 1. Growth of Pea Roots After Exposure to Two Concentrations of NP

	NP-I		NP-III		CONTROL
	100 ppm.	1000 ppm.	100 ppm.	1000 ppm.	
Mean length of shoot	9.8 cm.	7.2 cm.	8.0 cm.	6.0cm.	14.0 cm.
Mean length of root	9.0 cm.	9.2 cm.	9.4 cm.	10.1 cm.	13.6 cm.
Percent of Roots Growing Upward	38	50	60	40	0

At the end of a four week recovery period the epidermal and cortical layers of the root in the colored region burst and clusters of secondary root initials developed. In some regions, approximately 1 cm. in length, as many as sixteen such initials were found.

The Meristem of secondary roots often was multiple. In other cases, two to four rootlets fused to form a common meristem. Similar divisions and fusions were noted in shoot meristems which had not received direct application of the chemical.

Cytological examination showed that NP caused a lowering of the mitotic index to about one half that of the controls at the end of the twenty-four hour treatment period. There appeared to be little other effect on nuclear division since the majority of the mitotic figures were classifiable as normal.

Peas grown in soil, in greenhouse flats or in field plots, following a pre-emergence application of six pounds of NP per acre showed considerable reduction in emergence. Those which emerged were stunted, somewhat chlorotic, and frequently showed multiple shoot formation. The root system consisted of large clusters of subsurface rootlets which did not grow normally downward. Many of the plants reached a height of six to eight inches but were brittle and broke at the soil line when disturbed by tillage or strong winds. Some plants flowered and produced pods that were apparently normal. Yield records were not obtained because of severe damage from an accidental application of DDT spray.

The results of the Amziol tests indicate that the chief effect of this compound is to reduce the mitotic index or frequency of mitotic figures. A treatment with 200 ppm. for 8 hours produced seedlings which grew normally during the recovery period. A concentration of 1000 ppm. induced a few mitotic abnormalities and stopped division by the end of six hours treatment. The seedlings produced no root growth from the treated region and shoot growth was only one third as great as most of the controls. Bleaching out of chlorophyll occurred by the end of one week after treatment. Treatment with 2000 ppm. caused a reversion of prophase and eventual dissolution of the nuclei. Cell division ceased after six hours of treatment and none of the treated plants recovered.

In field trials approximately normal emergence of peas occurred but all plants became yellow and died within ten days.

Summary

These results indicate that, while the effects of NP on the mitotic processes are relatively mild, the compound should be classified as a suppressor of nuclear division. A more serious effect is the disturbance of polarity which developed in both root and shoot tips. This absence of response is probably responsible for the poor emergence of seedlings from soil treated with NP.

Amizol appears, from these limited tests, to be much more active from a cytological viewpoint than is NP. The effects probably are due to prophase poisoning and ultimate degeneration of the nuclei. Inhibition of chlorophyll formation may be due to a physiological block in the distribution of growth substances. These laboratory tests and field trials indicate that Amziol is not a suitable herbicide for use on peas. Further tests with other types of crops are needed before a proper evaluation of this compound can be made.

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1/ Journal Article No. 1701, Michigan Agricultural Experiment Station

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A PROGRESS REPORT OF FIELD EXPERIENCES WITH SILVEX

L. L. Coulter and J. W. Gibson 1/

Successful brush control experiments with esters of 2, 4, 5-trichlorophenoxypropionic acid were reported at the close of the 1953 growing season. (1-5) The common name of silvex was coined for 2, 4, 5-trichlorophenoxypropionic acid and a propylene glycol butyl ether ester formulation was subsequently made available under the trade name of Kuron. In parallel experiments, 2, 4-dichlorophenoxypropionic acid esters were also found to be an effective herbicide although more specific in range of activity. The propylene glycol butyl ether ester of this compound was made available to research workers in 1954, but has not been used commercially.

The field performance of the phenoxypropionic compounds including silvex and 2, 4-dichlorophenoxypropionic acid is of interest to research workers, as well as commercial users and this paper is intended as a general summary of this performance. Inasmuch as the more extensive research and commercial use of silvex has largely taken place during 1954, evaluation of these results are preliminary in nature. However, these observations in conjunction with results from earlier tests render it possible to make a fairly accurate evaluation of silvex as a brush killing agent.

Nature of Silvex Action

The relatively slow action of the propionic compounds is a unique characteristic of their activity on most woody plants. Observations of plants a short time after treatment indicate that these materials may cause a typical growth regulator reaction such as twisting and drooping of the leaves, however, actual kill of the leaves and stems is normally considerably slower than from similar 2, 4, 5-T or 2, 4-D treatment. This particular phenomenon is often carried through to the second year where the bases of old sprouts often remain green, although the tops are killed and the plant completely devoid of leaves. These stems often gradually die and turn brown during the second season. Resprouting is also slower and the growth from the root collar of such species as oak may be delayed a year longer than with 2, 4-D or 2, 4, 5-T.

Herbicidal Activity

A summary of the relative activity of silvex, 2, 4-dichlorophenoxypropionic acid, 2, 4-D and 2, 4, 5-T on three groups of woody plants is presented in Table 1. This table gives a composite relative rating of each compound from several tests where the activity is expressed as a percent of the 2, 4, 5-T activity for each species.

Table 1. Relative activity of phenoxyacetic and phenoxypropionic esters on three groups of woody plants:

	Oak*	Maple**	Aspen***
2, 4-D	70	20	100
2, 4, 5-T	100	100	100
Silvex	160	120	90
2, 4-dichloro-phenoxypropionic-acid	120	40	20

*Primarily deciduous oaks: Quercus alba, Quercus ellipsoidalis, Quercus marilandica, Quercus minor.
**Acer rubrum, Acer saccharum.
***Populus tremuloides and Populus grandidentata.

Herbicidal Effectiveness on Oak: Silvex is clearly more effective on this group of oaks than either 2, 4-D or 2, 4, 5-T. Silvex activity on northern deciduous oaks has often been as much as 3-4 times that of 2, 4, 5-T; while on post and blackjack oaks of the cross-timbered area, the differences have not been as great. (6) (7) 2, 4-dichlorophenoxypropionic acid has not shown the degree of activity that silvex has on deciduous oaks; however, it has been comparable to 2, 4, 5-T and significantly more effective than 2, 4-D. Observations by Leonard indicate that chlorophenoxypropionic compounds have been superior to the phenoxyacetic compounds in the control of the interior live oak (Quercus wislenzii) of California. Root-kill has been higher and translocation was more extensive in sprouts not killed. (9)

Herbicidal Effectiveness on Maple: The maples have been effectively controlled only with silvex or 2, 4, 5-T. This group of plants has often responded slightly better to silvex than to 2, 4, 5-T (8). However, differences have not been great. Both materials have given very good top-kill, but resprouting has developed lower on the plant when silvex has been applied indicating a greater downward translocation. While neither 2, 4-D nor 2, 4-dichlorophenoxypropionic acid have given effective top-kill on maple, greater activity has been exhibited by 2, 4-dichlorophenoxypropionic acid.

Herbicidal Effectiveness on Aspen: Aspen has been more resistant to foliage sprays of the phenoxypropionic acids while it is notably susceptible to 2, 4-D or 2, 4, 5-T. Response of this species to silvex has been very slow and

some plants have produced new growth near the base of the plant. This compound has, however, given satisfactory control in the range of 75-90 percent root-kill. On the other hand, 2, 4-dichlorophenoxypropionic acid esters have been virtually ineffective and root-kill has been in the range of 15-20 percent.

The chlorophenoxypropionic acids have been inferior to 2, 4-D and 2, 4, 5-T on white or green ash, aspen, coral berry and chickasaw plum, while showing a high degree of activity on oak and maple. This possibly indicates that these materials may be more selective or more specific in their action than the acetic compounds. For example, the selectivity observed with the 2, 4-dichlorophenoxypropionic esters suggest their use in suppressing competition of oak in stands of aspen grown for pulpwood. Future research may determine that the chlorophenoxypropionic acid compounds are effective on woody plants or perennial weeds which have been resistant to chlorophenoxyacetic acids.

It has long been noted that, with specific exceptions, 2, 4-D is generally more active on herbaceous plants than 2, 4, 5-T. However, field tests with silvex and 2, 4-dichlorophenoxypropionic acid have indicated that the opposite is true among the chlorophenoxypropionic compounds. Silvex has been more efficient on a wide range of species than 2, 4-dichlorophenoxypropionic acid; the latter has been relatively inactive on a number of herbaceous species generally regarded as susceptible to the chlorophenoxy herbicides.

Limited experimental work to date seems to indicate that silvex is not particularly efficient as a basal spray or stump spray. When used in this manner it has been virtually ineffective on ash, and it has controlled elm, dogwood, and maple with a moderate degree of success. Here again, it is of interest to note that the speed of action has always been much slower than that of 2, 4, 5-T or 2, 4-D. Oaks which have been treated with a basal spray of Kuron in oil have shown considerable foliar development during the growing season following the dormant treatment and in many cases the leaves have not died until the end of the growing season. This is in contrast to 2, 4, 5-T which normally prevents development of leaves during the season following the dormant basal treatment or kills them during the early weeks of the spring period.

While silvex has been more efficient as a foliage-stem spray for the control of oak in most cases, it does not necessarily follow that it is effective over any wider range of conditions than 2, 4, 5-T. In fact, it has been observed that silvex is influenced by the same environmental factors which influence the activity of 2, 4, 5-T or 2, 4-D. In tests which have been conducted during excessively dry periods where results from all compounds were relatively poor, results with silvex have been equally poor.

In brief, observations during 1954 substantiate the earlier promise of silvex for control of oak. They indicate that both silvex and 2, 4-dichlorophenoxypropionic acid are worthy of further consideration in control of problem species which have been resistant to the phenoxyacetic compounds. They are intriguing compounds for the research worker and silvex is a valuable tool for the commercial operator.

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AERIAL APPLICATIONS OF HERBICIDES ON OAK IN OKLAHOMA

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The use of airplanes to apply herbicides as foliage sprays to control oak brush and trees present many problems. A major difficulty has been the prevention of drift to adjacent areas while the spray is being applied. Another has been securing good coverage of each plant.

These problems, along with type of aircraft, spraying equipment, volume of spray, and flight swath required to produce satisfactory results, have not been fully investigated. However, the preliminary results and observations obtained thus far are given in this report. The amount of herbicide and the number of applications required to produce satisfactory results are also discussed.

Preliminary investigations in the use of airplanes to make treatments on brush were conducted cooperatively by the Red Plains Conservation Experiment Station and the Agricultural Experiment Station of the Oklahoma A. and M. College from 1947 to 1951. The information gained from these studies was used in setting up some large scale ranch tests in 1952. Groups cooperating in this work are given in the acknowledgement footnote.

Location of Test Areas

The sites selected for the large scale airplane spraying studies were areas covered with post oak and blackjack types of brush and small trees. There are seven million acres of this low-production brushland in Oklahoma and three million acres in Kansas and Texas. Much of this land would produce good grass if the brush were controlled. The location at Alex is in the southwestern part of the brush area. The one at Bristow is in the central part; and the one near Pawhuska is in the northeastern section. In addition, applications were made on the Red Plains Conservation Experiment Station and on a cooperator's ranch in the Oklahoma County Soil Conservation District.

Plans for the Study

The initial plots for the ranch tests were 20 acres in size. Eight different treatments were made in 1952 at three locations. At the Guthrie station and at the location in Oklahoma County, 5 acre plots were treated. New treatments in 1953 and 1954 on ranches were on 5 acre plots. The length of the plots varied from one-quarter to one-half mile.

Herbicides Tested: The herbicides used at all locations were low-volatile esters. The major applications were with 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) or an equal mixture of 2, 4-dichlorophenoxyacetic acid (2, 4-D) and 2, 4, 5-T. A few treatments were also made with 2, 4, 5-trichlorophenoxypropionic acid (2, 4, 5-TP). The chemical for each amount was mixed with sufficient diesel oil to make 1 gallon emulsified in 4 gallons of water, which was applied at 5 gallons per acre. The rate per acre and number of treatments for each chemical are given in Tables 1, 2, and 3.

Equipment Used: The main treatments in 1952, 1953, and 1954 were applied with a modified Stearman airplane. The modifications included a high lift wing section design and squared wing tips. These plane modifications were made by the Aerial Applicator's Association and the USDA Aircraft and Special Equipment Center at Cimarron Field, Oklahoma City, Oklahoma. The distribution system included an improved hydraulically driven pump and a boom equipped with 5 nozzles delivering 5 gallons per acre in a 33-foot swath.

At the start of the field applications in 1953, the plane was equipped with a fourteen nozzle boom; however, after three plots were sprayed, it was changed back to the 5-nozzle system. To compare the applications effected by the Stearman and a Cub airplane, additional treatments were made in 1954 by a 125-horsepower Cub plane equipped with a boom and nozzle as similar as possible to that on the Stearman. The only variation was the use of a propeller driven gear pump on the Cub. The rate and swath width were the same for both planes. The Cub plane was equipped and furnished by the Aircraft and Special Equipment Center.

Conditions During Treatments: Soil moisture was generally favorable for active growth when the 1952, 1953, and 1954 applications were made. They were made each year at the various locations from the first to the middle of June. The spraying was done early in the morning or late in the evening, when the relative humidity was high and wind velocities were less than 5 miles per hour. A rain of about one-half inch occurred immediately after two of the areas at Alex had been sprayed in 1954. The remaining areas were sprayed after the rain.

Drought prevailed each summer after the treatments were applied at all locations except at Pawhuska in 1954. During the summer months of that year, the area treated there received about normal rainfall.

The aerial applications from 1947 through 1951 were made at various periods during winter months, early spring (the bud break stage), late spring, and late summer. These early tests were made with various types of airplanes.

Procedures used in Determining Results: A rating system of numbers from zero through ten was used to classify the various degrees of defoliation. The graduations started from zero or "no effect", and increased ten per cent for each consecutive number up to ten, which represented complete defoliation.

These readings were taken in September by three to four observers working independently. For each treatment, they rated the plants in 9 belts 12 feet wide and 100 feet long. Due to the heavy density of small brush at the Pawhuska location, the reading there was made in a belt only 6 feet wide. However, for the counts of trees, the 12-foot belt was continued.

Checks were taken on the untreated areas at each location. The chief causes of apparent kill of plants in the untreated areas appeared to be fire (occurring two to three years prior to the start of spraying), and recent droughts.

The grass improvement on most of the treated areas was not determined since they were grazed, and severe droughts occurred during the summer at Bristow and Alex. However, forage samples of the grasses, native legumes, and weeds on treated and untreated areas were taken on ungrazed sites on the ranch near Pawhuska.

Results

The greatest effectiveness of all herbicides tested was from the repeated applications. Results of defoliation and apparent kill obtained with the various kinds, amounts, and different treatments of herbicides used are given in Tables 1, 2, and 3. The 2, 4, 5-T alone and the equal mixture of 2, 4-D and 2, 4, 5-T produced the most control from the three consecutive treatments. Two applications of the 2, 4, 5-T made in consecutive years gave a higher apparent kill than where a year without treatment occurred between them. This, however, was not true where the equal mixtures of 2, 4-D and 2, 4, 5-T were used. High amounts of acid in single applications of these herbicides gave very low apparent kills.

Based on comparable amount of acid, the 2, 4, 5-TP gave 17 per cent higher apparent kill than 2, 4, 5-T for averages of the three locations. Repeated treatments at Pawhuska with the 2, 4, 5-TP also increased control of the oak brush and trees. It was observed that white and post oaks were more readily affected by all the materials tested than were the blackjack, black, and chinquapin oaks.

There was little difference in results obtained with the two types of planes used (Table 4). Very little drift of spray occurred from the place where it was applied when the five-nozzle equipment was used. However, when fourteen nozzles were used on the Stearman, movement of the spray was traced to about one-quarter mile from point of application.

TABLE 1. Effect on Control of Brush and Trees of Repeated and Single Treatments Using Various Amounts of a Low-Volatile 2, 4, 5-T Ester; Alex and Bristow, Oklahoma, 1952-1954.

Pounds Acid per Acre				Percent of all Species 1/	
1952	1953	1954	Total	Defoliated	Apparently Dead 2/
1	1	2	4	85.5	62.3
2	2	-	4	63.6	58.1
2	-	2	4	75.6	40.3
-	2	2	4	80.4	46.5
2	1	-	3	59.1	46.7
1	-	2	3	72.1	40.7
3	-	-	3	29.8	16.4
2	-	-	2	25.6	16.6
1	-	-	1	26.5	7.8

1/ Average for the two locations. The species were 90 to 95 percent White, Post, Blackjack, Black and Chinquapin Oaks. Others were Elm, Hickory, Dogwood, Plum, Redbud, Sumac, and Chittum.

2/ Above ground growth completely killed. Untreated areas had an average of apparently dead plants of 4.3 percent.

TABLE 2. Effect on Control of Brush and Trees of Repeated and Single Treatments Using Various Amounts of Equal Quantities of Low-Volatile 2, 4-D and 2, 4, 5-T Esters; Pawhuska, Oklahoma, 1952-1954.

Pounds Acid per Acre				Percent of all Species 1/	
1952	1953	1954	Total	Defoliated	Apparently 2/ Dead
3.0	1.5	3.0	7.5	92.1	82.4
4.5	-	3.0	7.5	82.0	33.5
1.5	1.5	3.0	6.0	88.9	74.5
3.0	3.0	-	6.0	63.5	51.3
3.0	-	3.0	6.0	80.0	65.5
-	3.0	3.0	6.0	89.9	62.4
3.0	1.5	-	4.5	69.2	65.5
4.5	-	-	4.5	45.0	28.1
1.5	1.5	-	3.0	64.8	56.4
3.0	-	-	3.0	40.0	36.1

1/ The species were 75 to 80 percent Blackjack, Black, and Chinquapin Oaks; and 10 to 15 percent Post and White Oak. The remainder were Hickory, Sumac, and Greenbrier.

2/ Above ground growth completely killed. Untreated areas had an average of apparently dead plants of 19.5 percent.

TABLE 3. Comparison of Various Low-Volatile Ester Herbicides Applied in Foliage Sprays on Control of Brush and Trees; Oklahoma, 1953 and 1954

Location and Chemical	Pounds Acid per Acre			Percent of All Species 1/	
	1953	1954	Total	Defoliated	Apparently Dead 2/
Pawhuska:					
2, 4, 5-TP 3/	2	1	3	72.8	65.7
"	2	0	2	60.2	50.3
2, 4, 5-T 4/	2	0	2	52.1	25.7
2, 4-D and 2, 4, 5-T 5/	3	0	3	42.0	16.3
Arcadia, Alex and Bristow 6/:					
2, 4, 5-TP	2	0	2	62.8	37.3
2, 4, 5-T	2	0	2	46.0	31.9

1/ Species were 90 to 95 percent White, Post, Black, Blackjack and Chinquapin Oak; and others were Hickory, Sumac, and Greenbrier.

2/ Above ground growth completely killed. Untreated areas had an average of apparently dead plants of 19.5 and 4.3 percent, respectively.

3/ 2, 4, 5-trichlorophenoxypropionic acid. The Dow Chemical Company has proposed "silvex" as the common name for this herbicide.

4/ 2, 4, 5-trichlorophenoxyacetic acid.

5/ Equal parts of 2, 4-dichlorophenoxyacetic acid and 2, 4, 5-trichlorophenoxyacetic acid.

6/ Average for three locations.

TABLE 4. Comparison of Two Types of Planes Used to Apply Herbicides To Control Oak Brush and Trees

Plane 1/	Treatment 2/	Percent Defoliation 3/ Woody Plants			
		Alex	Bristow	Pawhuska	Average
Stearman	Retreatment on area previously sprayed	82.1	83.7	81.1	82.3
"	First Application	64.4	67.8	65.6	65.9
				Average	74.1
Cub	Retreatment on area previously sprayed	69.9	77.1	82.5	76.5
"	First Application	79.8	63.9	65.3	69.7
				Average	73.1

1/ Each plane had same general type of spray equipment.
2/ The herbicide applied at each location and for each treatment was low-volatile esters of 2, 4, 5-T at 2 pounds per acre at Alex and Bristow and an equal mixture of 2, 4-D - 2, 4, 5-T at 3 pounds per acre at Pawhuska. The spray at each location consisted of the chemical plus diesel oil to make 1 gallon with 4 gallons of water, applied at 5 gallons per acre.
3/ Results were determined from observations of the degree of defoliation.

The area at Alex, sprayed just before and after the rain, had respective defoliation of all plants of 75 and 61 per cent.

The most effective spraying has resulted from applications made during the period of active growth of the plants. This has been just after the oaks have reached full leaf size and before the terminal buds set and stopped the elongation of the twigs. Thorough coverage of leaves and twigs has been essential to obtain maximum results. These conclusions are based on the studies of serial applications of herbicides from 1947 through 1954.

Good increases of little and big bluestem, Indiangrass, switchgrass, and other types of desirable forage have occurred following the spraying with all herbicides used. These plants generally develop a protective ground cover the first or second year after the treatment. However, the drought and continued grazing on most of the treated areas prevented securing good measurements of the grass increase.

The clippings taken on the ungrazed sprayed areas at Pawhuska showed an increase in forage production of native grasses of 3.5 to 4 times over the untreated. This increase occurred the second season after treatment. Re-establishment of grasses was from suppressed plants existing in brush prior to its control with the herbicides.

There was an average of about 2,800 pounds per acre of brush 0 to 2 inches in diameter in the understory prior to the spraying at Pawhuska and Bristow.

Summary

The selective, low-volatile ester of 2, 4, 5-trichlorophenoxyacetic alone, and an equal mixture of 2, 4-dichlorophenoxyacetic and 2, 4, 5-T, or 2, 4, 5-trichlorophenoxypropionic acid were applied with airplanes to study their effects on control of oak and on grass development in Oklahoma. The greatest effectiveness of all herbicides tested was from repeated applications. The treatment of the oaks has resulted in development of good grass covers in one to two years. When applied in equal amounts, the 2, 4, 5-TP usually has given slightly better control of all the oaks than the 2, 4, 5-T alone or the 2, 4-D - 2, 4, 5-T mixture. All of these herbicides were somewhat more effective on post and white oaks than on blackjack, black, and chinquapin oaks.

Satisfactory brush and tree control was obtained from 2 pounds of acid per acre of either 2, 4, 5-TP, or 2, 4, 5-T. Where a mixture of 2, 4-D - 2, 4, 5-T was used, 3 pounds of acid were necessary for initial treatments. All treatments were more effective when followed the second year with applications of 1 to 2 pounds of acid per acre.

On areas heavily infested with woody species, 1.5 to 2 pounds of acid per acre of either the 2, 4, 5-T or 2, 4-D - 2, 4, 5-T mixture applied each year for three consecutive years produced very good results.

A spray solution, consisting of the chemical and sufficient diesel oil to make one gallon with 4 gallons of water, applied at the rate of 5 gallons per acre, gave satisfactory results. This spray, delivered through 5 nozzles in swaths of 33 feet, produced good coverage of the foliage. Very little drift of spray occurred from the place where it was applied when the five-nozzle equipment was used. However, when fourteen nozzles were used on a Stearman plane, movement of the spray was traced to about one-quarter mile from point of application.

There was no difference in coverage and control of spray from comparable applications made with either a Cub or Stearman plane.

A rain of about one-half inch, occurring one-half to one hour after the herbicides were applied, did not reduce their effectiveness.

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INTERIM REPORT ON SHINNERY OAK CONTROL STUDIES IN THE SOUTHERN GREAT PLAINS 1/

E. H. McIlvain 2/

Eight different species of shinnery oak, Quercus, contaminate 8,800,000 acres in Texas, about 5,000,000 acres in New Mexico, and 1,000,000 acres in Oklahoma. Dense stands of shinnery oak often cut range forage production more than 90 percent, and in addition, the brush is extremely poisonous to livestock in early spring. Stockmen have long wished to kill this pest, but all eradication methods except literal plowing have proven unsuccessful.

Shinnery oak usually grows on sandy soils with relatively shallow clay layers near the surface. However, it may grow on extremely deep blowsands. It thrives in areas of annual precipitation varying from 15 inches in New Mexico to 25 inches in Oklahoma. In central Texas and Oklahoma, it gives way to taller forms of oak such as blackjack and post oak.

The brush varies in growth form from insidious, low, scattered plants to extremely heavy, dense, almost tree-like growth. All growth forms compete seriously with good forage plants for soil moisture, nutrients, and sunlight.

The root system of shinnery oak is tremendous. It has both wide-spread, lateral roots close to the surface of the ground and well-developed, vertical, tap roots which penetrate 15 to 20 feet into the soil. Some of the roots are as big in diameter as a man's thigh; these may occur on plants with above-ground portions no more than 2 feet tall and with individual stems not thicker than a pencil. The lateral roots are capable of sprouting along their entire length. This rooting habit has enabled shinnery oak to survive the elements as well as man's attacks.

The plant is poisonous to livestock during late March and early April, its flowering period, which precedes formation of new leaves. The plant causes more poisoning in some years than in others. In 1948, 200 head of breeding cows were killed by shinnery oak in Ellis County, Oklahoma, alone. Similar losses occurred in 1954. Some years the loss in this county is only one-tenth that much. The poisonous substance in shinnery oak is tannin which exerts its deadly influence through a tanning process somewhat similar to the commercial manufacture of leather. The intestinal tract of livestock becomes tough and thickened with resultant emaciation and death.

Grass growing in chinnery oak is much less nutritious than grass growing in open sunlight. The effect of shade is to increase fiber content and lower sugar content greatly. Consequently, livestock reluctantly graze these shaded grasses. Instead, they concentrate in open areas where the grass is weakened and often killed by heavy grazing use.

Shinnery oak is not a rapid invader of grassland. Its range has not increased perceptibly in recent years even though it has thickened in stand in many localities. Once it is eradicated, it does not reinvade the area rapidly. Old fields cultivated about 1900 and then abondoned after a few years of cultivation have often returned to solid stands of grass even though dense stands of shinnery oak surround the fields on all sides.

Early Control Methods

Control of shinnery oak by fire was used in early days of settlement of the Southern Great Plains. Fire reduced the stature of the plants but caused it to re-sprout vigorously. Top growth often grew 3 to 4 feet high within two to three years after a burn. During this brief period, however, grass growth increased surprisingly well if grazing pressure was moderate.

Today, the most progressive operators use the following method for burning shinnery oak with some success. The area to be burned is grazed lightly for a full year so that sufficient grass remains on the land to carry a hot fire. After fireguards are constructed, and when the ground is damp, the area is fired in late March or early April. Grazing is then deferred until fall. The area is re-burnt about once every 5 years. This method does not kill the shinnery or solve the problem, but it does hold it in check so that a fair quantity of grass can be grown. Burning is no doubt responsible for thickening up of many shinnery stands to the point where ultimately little forage is produced.

Many different kinds of mowers, beaters, cutters, choppers, and other mechanical devices have been unsuccessfully used to control shinnery oak. Mowings in consecutive years and successive mowings within one year, often repeated for several years, have had little effect in thinning the stand. As with fire, removal of top growth of shinnery permits grasses to produce more forage. This practice is primarily used in the eastern portion of the range of shinnery oak where rainfall is high and potential production is good. However, the economics of the practice are questionable, and ".... once vigilance is relaxed it silently resumes the throne from which it has been expelled but which it never abdicates."

Goats have been used in Texas for many years to kill brush, including some species of oak. The brush ranges are divided into small pastures that can be heavily overgrazed, at an intensity of about 3 goats per acre, until the browse sprouts are completely consumed, then the goats are moved to another area. Of course, this treatment is rather hard on the goats but it is sometimes economically possible to eradicate the brush without irreparable damage to other forage plants!

Chemical Control Appears Promising

Since 1947, over 700 plots of shinnery oak have been experimentally sprayed with chemicals by research personnel of the U. S. Southern Great Plains Field Station, Woodward, Okla. Sprayings were made monthly throughout the year, and many different formulations and rates were used. Combinations of hormone chemicals, contact sprays, wetting agents, and spreading agents were

employed. Repeat sprayings were made of the most promising treatments for 3 successive years. Herein seems to lie the success of chemical control.

Date of Spraying: Although a single spray application of any formulation was barely discernible 2 years after it was applied, it was observed that spraying in late May or early June was most detrimental; top kills up to 90 percent were occasionally obtained. Dormant-season spraying retarded early spring growth for 2 to 3 weeks but usually did not kill any of the top growth.

Kind of Chemical: The chemicals 2, 4-D and 2, 4, 5-T were equally effective in retarding or killing top growth. There is little difference between these two chemicals so the lower cost of 2, 4-D makes it the more promising chemical. Mixing 2, 4-D with combinations of 2, 4, 5-T, ammonium sulfamate, TCA, or other chemicals did not increase effectiveness. The low-volatile esters of both 2, 4-D and 2, 4, 5-T appear to be much more effective than the ethyl, butyl, or isopropyl esters. Although the low-volatile esters are more expensive, it appears their use would be worthwhile as explained later.

Rate of Chemical: Rates varying from 1/16 pound to 25 pounds per acre of both 2, 4-D and 2, 4, 5-T were applied to shinnery oak. Surprisingly, 1/16 pound of 2, 4-D applied in early June wilted the current crop of leaves and retarded growth perceptibly the following spring. Increased amounts of 2, 4-D up to 1 pound per acre caused appreciably more detrimental effect. However, two pounds per acre was only slightly more effective than 1 pound. Higher rates were of little additional value until the rate was reached where nearly all vegetation was destroyed. There was some indication that rates above 2 pounds per acre were less detrimental than the 1 and 2 pound rates.

Kind of Carrier: The chemicals were applied in water alone; in water emulsified in varying quantities of diesel oil; in diesel oil alone; in several types of agricultural oils such as Shell's ACX-170; Standard Oil's Esso Weedkiller 35, Esso Weedkiller 45, Mentor 26, Spray Oil 16; and special oils used by the P-T Air Service of Hays, Kansas, and the Agricultural Chemical Company of Des Plaines, Illinois. These experimental oils were designed or reputed to be less phytotoxic than diesel oil or kerosene. Water alone was not as effective as the water-oil emulsion, but there was little difference between the water-oil emulsions and the various types of oil used alone. The bland oils resulted in slightly more mortality than did diesel oil, but none of them were the crux of the problem. The most economical carrier was the emulsion; whereas, the easiest solution for use by most airplane applicators was straight diesel oil.

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Repeat Sprayings: Several of the most effective treatments were applied at the most promising date for 3 successive years, 1949-50-51, with astounding effects. Resultant top kill was 100 percent and root kill was usually a satisfactory 80 to 90 percent. The few remaining sprouts were weakened severely, and they offered only token competition to the grass, even in 1954. Two annual sprayings of low-volatile esters were as effective as 3 annual sprayings of the volatile esters. Apparently the key to chemical control of shinnery oak with the chemicals available today is to keep it underground to starve the roots.

Suggestions for Limited Trials

Although conclusive recommendations cannot be made for absolute control of shinnery oak the following suggestions are offered for those who wish to make limited trials: Spray shinnery oak for 3 consecutive years between May 15 and June 15 with 1 pound per acre of 2, 4-D acid equivalent in the volatile ester form in 3 to 5 gallons per acre of diesel oil or in an emulsion of 2 to 4 gallons of water and 1 gallon diesel oil. Or if desired, spray for 2 consecutive years with a low-volatile ester of 2, 4-D. Remember, cotton grows near many shinnery areas! Experienced aerial applicators should do the work.

Adequate rainfall and good growing conditions in early spring are essential for satisfactory results. Should the brush be growing poorly during any one of the three years, it is advisable to skip that year in the spraying program.

Annual costs will run about $2.50 per acre for the 3 sprayings, or slightly more for the low-volatile esters. Returns from the investment are realized soon after the spray is applied, because the growth of shinnery oak is curtailed immediately. Even when top kills were nil, grass growth improved greatly following spraying. Because shinnery land looks so worthless, it can be purchased cheaper than most other types of rangeland today. However, indications are strong that $7.50 per acre -- the cost of 3 successive sprayings -- will turn shinnery country into some of the finest rangeland.

1/ Based on investigations conducted at the U. S. Southern Great Plains Field Station, Woodward, Okla., by the Forage and Range Section and the Weed Investigation Section of the Field Crops Research Branch, Agricultural Research Service, USDA in cooperation with numerous agricultural chemical companies, airplane applicators, and ranchmen of the region.

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CHEMICAL ERADICATION OF HAWTHORN

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Hawthorn or thorn apple, (Crataegus sp.) is a major pasture pest throughout much of Eastern and Northern Ohio. This paper reports a study of the rate and method of application of long-chain low-volatile esters of 2, 4-D, 2, 4, 5-T, and of "brush killer", on hawthorn at different seasons of the year.

Foliage applications

2, 4-D and 2, 4, 5-T were applied to hawthorn at various periods during the spring and summer in both water and oil sprays, and also in a 10% oil-water emulsion. Without going into the details of these experiments, a solution of either of these materials at 4 pounds ahg of water gave excellent results, but more dilute sprays were of less value. There was little advantage in the oil or oil emulsion sprays, except that they killed the foliage faster.

These applications were made at different times of year with equally good results. There was frequently sprouting from the base and some sprouting elsewhere, so some retreatment would probably have been necessary. Nevertheless, summer spraying of the leaves proved to be an effective method of treating hawthorn. These experiments showed, as have others, that thorough coverage of the entire leaf canopy was necessary for success.

Basal applications

A series of experiments was carried out with different amounts of spray containing different amounts of herbicide in an attempt to determine the most economical methods of basal treatment. Three rates of applying the spray solution were used, one in which the trunk was barely wet, one in which the spray was applied until the beginning of run-off, and one in which the spray was applied until there was a considerable run-off. The amounts of spray used per inch of trunk diameter by these methods were in the ratios 1: 2: 3. These different amounts of spray solution were applied high on the trunk (18 inches) and low on the trunk (2 inches, or as low as possible) using the same amount of spray in each instance. Sprays were applied containing 2, 4-D, 2, 4, 5-T, and brush killer at 2 to 16 pounds ahg of No. 2 fuel oil, and 2, 4, 5-T was also applied at 32 and 48 pounds ahg of oil.

These tests showed: (1) As long as the same amount of material was applied there was no difference due to the height on the trunk to which it was applied - in other words, as long as the spray is put on the lower part of the trunk the exact amount of trunk covered is immaterial; (2) The volume of spray applied was very important. It seemed essential to have sufficient spray applied at the base of the plant to work down along the roots, if a satisfactory kill of both roots and tops was to be obtained. For example, 2, 4, 5-T at 4 pounds ahg applied in high volume was considerably more effective than 2, 4, 5-T at 32 pounds ahg in low volume, although approximately three times more 2, 4, 5-T per tree was used with the low-volume high-concentration solution than with the high-volume low-concentration solution.

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For basal treatment, brush killer or 2, 4-D at 8 pounds ahg in fuel oil or kerosene was sufficient if applied at high volume so that there was considerable run-off. The same solution was effective on hawthorn stumps.

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A study was set up to provide comparisons of cost and effectiveness of brush control methods and equipment. Of possible interest to all agencies concerned with brush control, this study was primarily designed to provide the answer to the farm operator's problem in choosing a method and appropriate equipment for comparatively small scale brush control for improving pastures and range. An equally important purpose of the study was to provide a basis for determining the advantages and needed improvements in the equipment which was used.

The test was located in a pasture in which the marketable timber had been removed approximately 18 years previous. During the intervening period the area had apparently been heavily over-grazed and as a result had regrown to brush which was about 85% hickory (Carya sp.). The remaining growth consisted of sparse stands of oak, persimmon, red cedar and others. The brush size ranged from bush type growth to 5 to 6-inch trees 25 feet tall. The stand per acre on the test plots ranged from 1300 to 2300 stems. There were 5 to 7 60-foot oaks per acre which had apparently been left in the first cutting as unmarketable at that time. No effort was made in the application of these treatments to remove these large trees as they now have a possible market value. Aside from these large oaks, the growth was considered to have no value as timber. The area is in the river hill section along the Missouri river and has a loess type soil fertile enough to produce good grass under favorable conditions.

There were six treatments in the study, including four dormant season and two growing season applications. The chemical used for all treatments was 2, 4, 5-T propylene glycol butyl ether ester. The treatments, equipment and herbicide rates used in the application were as follows:

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3. Foliage handgun treatment (FH) - applied with a tractor mounted sprayer equipped with a trigger type handgun - 3# ahg water. A row crop tractor was equipped with a power take-off pump and a rear mounted rack

supporting two 50-gal. barrels. A trigger type adjustable spray handgun fitted with a .098" orifice and attached to a 50-foot hose was used to apply the spray at 120 psi.

4. Foliage boomless nozzle treatment (FBn) - applied with a boomless type nozzle supported atop a 22' tower mounted on a row crop tractor - 10# ahg 10% emulsion. The tower which was attached to the barrel rack consisted of a tripod base 12' high supporting a 10' section of 1 1/4" pipe. The total height of the nozzle from the ground was 25'. This placed the nozzle above most of the brush. The nozzle was calibrated to deliver 30 gal. per acre with a 40' swath when operated at 40 psi and at a speed of 2 mph.

5. Basal handgun treatment (BH) - applied with a tractor mounted sprayer equipped with a handgun - 10# ahg oil. This equipment was the same as was used for the foliage handgun treatment. The handgun was operated at 30 psi with the operator spraying the lower 12 inches of stem at distances of 4 to 15 feet. An attempt was made to spray the full circumference of the stem to the point of runoff.

6. Basal knapsack treatment (BK) - applied with a 3 gal. knapsack sprayer - 16# ahg oil. The sprayer was equipped with an adjustable nozzle set to produce a spray cone of approximately 30°. This nozzle was mounted at a 45° angle with the wand to aid in reaching all sides of the stems. The spray was applied at 20-25 psi to the lower 10 inches of stem until some runoff was noted.

In all treatments the herbicide rate was chosen after a review of the recommendations and research reports of several workers (1...9). Although three treatments (basal handgun, boomless nozzle and notch oilcan) are not included or favored in present recommendations, research reports would indicate that there is a good possibility that either one or all of them may become good methods of brush control.

In this study, a time record was kept on all operations to aid in determining the relative cost. Observations were made during the application for any notable advantages and disadvantages of the equipment. Application of all dormant treatments was made in February 1954. The foliage treatments were applied in June 1954. Defoliation results were taken to determine the first year's effectiveness of the various treatments. The results of the cost and effectiveness study are given in Table 1:

In studying the results shown in the table, it is perhaps most notable that the NOC treatment, while using the greatest amount of herbicide per acre, gave the second lowest first-year defoliation. All trees treated by this method produced normal leaves early in the season, but continuously improved in defoliation as the summer progressed. In the C&S treatment the deep leaf cover on the ground made it very difficult to locate and spray all of the stumps. The records show 2.2% of the stumps were not sprayed. This inability to locate all of the stumps could be one of the major causes of poor results for this treatment. Each stump could be sprayed as it was cut, but this would be time consuming and add considerable to the cost of the treatment. The FBn treatment is reported as the lowest in cost, but also produced the lowest defoliation.

The application of the NOC treatment, with the oilcan and ax, required the operator to move about much of the time in a kneeling position to enable him to reach in under the lower branches of the trees. This could be very disagreeable under winter conditions and presents a need for improvement in the application equipment. The time of application and rate of herbicide also need further study.

The equipment used for the C&S treatment worked satisfactorily. As expected, the cost is very high and justification for field application would of necessity be for esthetic reasons or for the permitting of future operations such as fertilizing and seeding on the cleared area.

The BK treatment appears to be one of the best methods used as it gave the highest results at low cost. The adjustable nozzle operated to advantage. The need for an improvement of the spraying wand was evident. The knapsack sprayer tends to be rather uncomfortable when carried on the back of the operator, a feature which led to its being carried in one hand most of the time.

The BH treatment has an advantage in that the labor per acre was only a little over half of that required for the basal knapsack treatment. The reduction in labor time would tend to favor this method in view of present-day mechanization trends. The cost of the BH treatment is higher than that of the BK treatment. One of the factors responsible for a portion of the higher cost is the possible excess amount of herbicide applied per acre. The need for study to determine the proper rate is shown by an auxiliary exploratory study in which it was found that 5# ahg oil gave almost comparable results to the 10# ahg oil as applied in the original study. A rate of 5# ahg 10% oil-water emulsion plus 1% wetting agent gave considerably poor results. Further study should be made to determine the type of handgun best suited to this type of treatment.

Table 1. Results of Different Brush Control Methods on an Acre Basis

Treatment	Chem.[1]	#Chem	Gal Oil	Man hours	Mach cost	Total cost[2]	Stem/ acre	% defol[3]
BK	16# ahg oil	4.01	24.17	3.99	0.20	19.36	1540	97
BH	10# ahg oil	5.73	55.76	2.19	2.52	29.57	1692	95
NOC	4#/gal (undil.)	6.26	---	6.32	---	24.36	1988	63
C&S	16# ahg oil	1.61	9.69	33.38	3.61	43.08	1549	88*
FH	3# ahg water	6.18	---	2.79	3.20	23.79	1846	89
FBn	10# ahg 10% emul.	3.56	2.68	0.51	0.60	11.76	1788	56

1 2, 4, 5-T propylene glycol butyl ether esters
2 Total cost based on Chemical @ $2.88/lb, Labor @ $1.00/hr., Oil @ $0.15/gal.
3 September 1954 *Based on stumps not resprouting
Analysis of variance - Defoliation results - LSD - 5% level - 10.05
Cost results - LSD - 5% level - 8.25

The biggest problem encountered in applying the FH treatment was that of uniform coverage. The results apparently are very dependent on the operator's judgment as to what constitutes a drenching spray as is specified in many recommendations. There was indication of a need for further study of orifice sizes and pressures as a basis for providing more exact specifications for this treatment.

The FBn treatment rated second in the amount of defoliation per unit of cost. This treatment by virtue of its low labor requirement would seem to represent the best possibility for mechanizing brush control. To its disadvantage was the uneven application due to the operator's inability to maintain a straight swath through the brush. The row crop tractor was able to ride over 3 to 3 1/2 inch hickory trees but would have to be driven around all larger trees. In an auxiliary study a more uniform defoliation of 92% was obtained with the nozzle and tower mounted on a crawler type tractor which was able to maintain the planned 40-foot swath. Further work is necessary to determine the proper rate for this type application.

The conslusions drawn from this study indicate the basal knapsack treatment to be the best at the present time. There is a great need for further work on improving the equipment and techniques of all methods. By means of equipment improvements many of these treatments can be made more efficient for use in a practical brush control program.

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SOME EFFECTS OF BASAL AND FRILL TREATMENTS OF 2, 4, 5-T, AMMATE, AND CMU ON OAKS

S. Clark Martin and T. W. Jones 1/

Most of the results reported at this meeting are from studies in killing woody plants to permit more or better grass or timber to grow or to cut down the expense of right-of-way maintenance. The data I have are from part of our research program on oak wilt. As you know, the presence of the oak wilt disease is causing concern throughout the central hardwoods region. The responsible organism has been isolated and identified, and is known to be capable of spreading from tree to tree through root grafts. One way to stop the local spread of oak wilt is to kill all trees that have direct root contact with an infected tree. And the most promising way to kill these trees is with herbicides.

The objective of the study I am reporting here was to find out how effective were eight chemical treatments on three treatment dates. The treatments were applied to five size (diameter) classes of four species of oak in South-central Missouri.

The four species were: white oak (Quercus alba L.), post oak (Q. stellata Wangenh.), black oak (Q. velutina Lam.), and blackjack oak (Q. marilandica Muenchh.).

The five diameter classes were: 1-inch, 2- to 3 inch, 4- to 6-inch, 7- to 10-inch, and trees 11- inches and larger. Diameter measurements were made at breast height (d.b.h.), about 4 1/2 feet above the ground.

The three treatment dates were: June 1952, November 1952, and February 1953.

The eight chemical treatments were:

1. Ammate, 4 lb./gal. in low frill (about 6 inches above ground line)
2. Ammate, 4 lb./gal. in high frill (about 30 inches above ground line)
3. 2, 4, 5-T Ester, 12 1/2 lb. acid/100 gal. oil, in low frill
4. 2, 4, 5-T Ester, 12 1/2 lb. acid/100 gal. oil, as basal spray
5. 2, 4, 5-T Ester, 50 lb. acid/100 gal. oil, in low frill
6. 2, 4, 5-T Ester, 50 lb. acid/100 gal. oil, as basal spray
7. CMU, 1/2 lb./gal., in low frill
8. CMU, 2 lb./gal., in low frill

In the low-frill treatments, herbicides were applied at the rate of 1 gallon per 400 diameter inches. The basal sprays were applied at the rate of 1 gallon per 80 diameter inches. The low-frill treatments (on the 1-, and 2- to 3-inch trees) actually were cut-stump treatments.

Almost 15,000 trees were included in the main treatments. Each tree was numbered for positive identification. Each treatment group included 30 trees of the same species and d.b.h. class. Post-treatment data, which were recorded directly on IBM mark-sense cards, included percent of top kill, kind and number of trunk sprouts, and kind and number of basal sprouts. This report is limited to data on percent kill--that is the percentage of trees with dead tops and no live sprouts in September 1954.

Results

Overall averages in which all species, d.b.h. classes, and treatment dates are combined show that the four best treatments each gave about 75 percent apparent kill. This was decidedly better than any of the four least effective treatments. The best treatments were: 4-pound ammate in low frill, 2-pound CMU in low frill, 50-pound 2, 4, 5-T ester basal spray, and 50-pound 2, 4, 5-T ester in low frill (Table 1).

Table 1. Apparent Percent Kill (average for four species and three dates of application) by Treatments for Small Trees (1- to 3-inches), Large Trees (4-inches plus), and All Sizes Combined.

Treatment	D.B.H. Class (inches)		
	1 - 3	4+	All
Ammate, 4 lb. per gal. in low frill	90	64	75
Ammate, 4 lb. per gal. in high frill	-	56	-
2, 4, 5-T Ester, 12 1/2 lb. AHG[1/] in low frill	58	46	50
2, 4, 5-T Ester, 12 1/2 lb. AHG as basal spray	72	39	52
2, 4, 5-T Ester, 50 lb. AHG in low frill	73	72	73
2, 4, 5-T Ester, 50 lb. AHG as basal spray	92	63	74
CMU, 1/2 lb. per gal. in low frill	35	34	35
CMU, 2 lb. per gal. in low frill	68	78	74
Check	14	10	12

1/ AHG = Pounds of acid per 100 gallons.

The effectiveness of the treatments varied among diameter classes and species. On trees up to 3-inches d.b.h. the best two treatments gave about 90 percent kill and were the 50-pound 2, 4, 5-T basal spray and the 4-pound ammate on stumps. On trees 4-inches and larger the best two treatments gave about 75 percent kill and were the 2-pound CMU in low frill and the 50-pound 2, 4, 5-T in low frill.

The two best treatments for the 1- to 3-inch trees were the same for all four species of oak. But, in the larger diameters the best two treatments on white oak were not the same as those for post oak and post oak differed from blackjack oak and black oak. These and other differences among treatments and species deserve further comment.

Ammate Treatments

Ammate solutions, made up by adding 4 pounds of ammate to a gallon of water, were applied to low stumps of 1- to 3-inch trees, to low frills on trees 4-inches in diameter and larger and in high frills on trees 4-inches d.b.h. and larger. The percent kill for the stump treatments and low frill ranged from a high of 92 percent for 1-inch stumps to a low of 57 percent for trees 11-inches and larger. On the other hand, the percent kill for the high frill treatment ranged from a low of 41 percent for 4- to 6-inch trees to a high of 69 percent for trees 11-inches and larger. Thus, for some reason, the low frill was more effective on 4- to 6-inch trees but the high frill was better on trees 11-inches or larger.

The ammate stump treatments, which were limited to 1- to 3-inch trees, were highly effective on all species, the range in kill being from 87 to 94 percent. In the larger diameter classes, where frill treatments were used, kills on white oak and post oak were higher than for blackjack and black oak. This difference between the "white oaks" and the "black or red oaks" was greater for the high-frill treatment than for the low-frill treatment.

You will recall that the treatments were applied in June 1952, November 1952, and February 1953. The June 1952 treatment was noticeably less effective than the other two for the low-frill and stump treatments. The average percent kill for the four species ranged from 93 to 97 percent for the February and November stump treatments (1- to 3-inch trees). Comparable kills for the June treatments were 85 percent for 1-inch trees and 75 percent for 2- to 3-inch trees. The lowest kill (7 percent) was obtained on white oak trees 11-inches and larger which were low-frilled in June. There was little consistency in seasonal effects on the high-frill treatment. These data suggest that June is not the time for stump or low-frill treatments with ammate.

One question that always confronts us is how soon after treatment can we tell what our results are going to be? We observed the trees in this study in August 1953 and again in September 1954. Averages for all species taken together show higher apparent kill in 1954 than in 1953. The apparent increase in percent kill from 1953 to 1954 amounted to less than 5 percent for the small diameter classes. In the larger diameter classes the increase ranged from 8 to over 40 percent and increased with increasing diameter. Thus, our last year's appraisal of the ammate treatments was conservative for all diameter classes. Last year's figures were pretty good for the 1- to 3-inch stump treatments but were very poor for the large trees. In other words, one must wait longer for the final story on big trees than on little trees.

CMU Treatments

CMU suspensions, made up by adding 1/2 pound and 2 pounds of CMU (80 percent, wettable powder) to a gallon of water, were applied to the stumps of 1-inch and 2- to 3-inch trees and in low frills on the larger trees. At both concentrations the percent kill decreased as diameter increased. And at all diameter classes the high concentration gave much higher kills than did the low concentration. There also is some indication that the frill treatments are more effective than stump treatments, although no direct comparisons are available.

CMU was not among the best two treatments for any species in the 1-, and 2- to 3-inch diameter classes. In the larger diameter classes the 2-pound CMU treatment was the most effective for post oak, blackjack oak, and black oak, but ranked third for white oak. In fact, white oak (in both large and small diameter classes) appeared to be the species least susceptible to both concentrations of CMU.

June was the most effective treatment date for all CMU treatments. There were no consistent differences between the November and February treatment dates.

All 1953 observations on CMU treatments showed much lower kills than in 1954, regardless of type of treatment, diameter class, or concentration of chemical. In fact the 1953 figures on percent kill were so low as to be almost useless for evaluating the final effectiveness of the treatment. So, if you plan to use CMU in the way we have used it in this study, you should plan to wait 2 years for the results, maybe longer.

2, 4, 5-T Treatments

2, 4, 5-T, in the form of propylene glycol butyl ether esters, was applied in oil at concentrations of 12 1/2 and 50 pounds of acid equivalent per 100 gallons of oil in stump and frill treatments and as a basal spray. For the stump and frill treatments the 2, 4, 5-T solution was applied at the rate of 1 gallon per 400 diameter inches. The rate for basal spray was 1 gallon per 80 diameter inches.

At both concentrations the basal spray treatments were more effective than the stump and frill treatments for trees up to about 4 inches in diameter. Mortality for trees 7 inches or larger was greater for the frill treatments. This switch in the relative effectiveness of the two methods of application was due to a sharp decline in effectiveness of the basal spray with increasing diameter. Kills obtained with basal sprays were about the same for the 2- to 3-inch diameter group as for the 1-inch trees, but the percent kill declined rapidly with increased diameter thereafter. These data clearly indicate the superiority of frill treatments for killing trees larger than about 6 inches in diameter.

For the stump and frill treatments there was a less pronounced but rather consistent decrease in kill with increased diameter for the low concentration of 2, 4, 5-T. The high concentration of 2, 4, 5-T in frills was about equally effective for all diameter classes.

Of the four oak species in the study, blackjack oak was least affected by 2, 4, 5-T treatments. Mortality for blackjack oak trees, both large and small, was lower than for any other species at both concentrations in the frill treatment. The same is true for the small trees in the basal treatments. On the other hand, large white oak trees appeared to be harder to kill with basal sprays than did large blackjack oaks. Post oak apparently was the species most susceptible to 2, 4, 5-T treatments.

The effects of season on 2, 4, 5-T stump and frill treatments were somewhat inconsistent. Stump and low-frill treatments were most effective on the small-diameter classes in June. And, at the low concentration, 2, 4, 5-T frill treatments were strikingly poor in February. Basal treatments appeared to be about equally effective on the three treatment dates tested.

The percent-kill data for 1953 and 1954 for the 2, 4, 5-T treatments indicate that observed kills on basal treatments on 1-inch trees were about the same both years but that the later observation showed higher kills in the larger diameter groups. Trees in the 4- to 6-inch class and larger also showed higher kills in 1954 for the frill treatments. However, and here is the exception, the stump treatments on 1-, and 2- to 3-inch trees showed higher kills in 1953 than in 1954. In other words, some of the stumps that looked dead last year now have live sprouts.

Summary and Conclusions

I realize that I have been presenting a rather intricate array of results. I have presented a good many angles with the thought that even the more obscure points might be of interest to someone here. If nothing more, they may raise points for discussion. Even so I have presented only some of the more apparent results of this study. We plan to make a more comprehensive analysis of the data after next year's observation. For the time being, however, I will attempt to boil down the most significant results. You all realize, of course, that there are exceptions to most, if not all, of these summarizing statements.

Effect of tree size: In general the larger the tree the harder it is to kill, the longer it will take to die, and the less consistent the results.

Differences among species: Only a few differences among species stand out and these are not large enough to greatly influence the effectiveness of any treatment. White oak was the species least affected by CMU stump and frill treatments. Blackjack oak was the hardest species to kill with 2, 4, 5-T, except that large white oaks were even harder to kill with basal sprays than were large blackjack oaks.

Effect of month of treatment: Perhaps it should be mentioned that the study has been conducted during Missouri's worst recorded drought, so weather conditions may have affected results. Also, the June 1952 treatments are 8 months older than the February 1953 treatments, so time elapsed since treatment may also have a bearing on present results. However, when data for all treatments, species, and sizes are thrown together, June was the most effective month and February the least. One outstanding exception to this generality is that June is not the best time for ammate frill and stump treatments. This peculiarity of ammate is supported by results from an earlier study on post oak. Basal-spray treatments showed no consistent seasonal effect.

Concentration of herbicide: Two of the herbicides used in this study (CMU and 2, 4, 5-T) were employed at

two concentrations. In both cases the higher concentration gave higher kills. In neither case were the increases in kill proportional to the increase in the amount of chemical used.

Date of observation: Except for the 2, 4, 5-T stump treatments on 1- to 3-inch trees, the 1953 observations showed lower kills than did the 1954 observations. The differences were small for the 1-inch trees and increased rapidly with increased diameter. Apparently 1 year after treatment is much too early to judge the results of frill and basal treatments on large trees. CMU frill treatments are particularly slow to kill and would be greatly underrated if appraised after only 1 year treatment.

Most effective treatments: The four most effective treatments were:

1. Ammate, 4 lb. per gal. in low frill or stump---75 percent kill
2. 2, 4, 5-T, 50 lb. AE/100 gal. oil as basal spray---74 percent kill
3. CMU, 2 lb. per gal. in low frill---74 percent kill
4. 2, 4, 5-T, 50 lb. AE/100 gal. oil in low frill---73 percent kill

Of these, the ammate and 2, 4, 5-T basal spray were most effective on trees in the 1-inch and 2- to 3-inch diameter classes, while frill treatments with 2, 4, 5-T and CMU were most effective on trees 4 inches in diameter and larger.

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BASAL SPRAYS AND INJECTION TREATMENTS ON TREES1/

L. S. Gleason and W. E. Loomis 2/

Basal spray treatments were compared with a chipping or injection treatment, developed at the California Station, for killing small trees in Iowa.

Basal sprays were applied with a special spray chamber which held a measured quantity of spray, determined by the treatment and the circumference of the tree in inches at breast height. In the injection treatments notches were cut in the bark of the trees with a single stroke of a narrow bladed hatchet and a measured quantity of 2, 4-D or 2, 4, 5-T concentrate was applied in these openings. An attempt was made to place the herbicide in the region of the cambium, and notches were cut at varying intervals around the circumference of the trees.

Basal Sprays

Basal sprays were applied at 3 rates, 0.06, 0.12, and 0.24 grams of chemical per inch of circumference. Chemicals were 50% 2, 4, 5-T ester brush killer or the straight 2, 4, 5-T ester. Three oils were used as carrier, diesel fuel, a light catalytic oil comparable to diesel fuel except for a 50% aromatic content, and an aromatic oil of higher boiling point range. Oils were used at the rate of 3, 6, or 12 ml. per inch of circumference, so that rates of chemical and rates of carrier were combined factorially. Six species were used with American elm the most important, and treatments were applied in late winter, full leaf in late May, or leaf senescence in late September.

The results of basal stem treatments were evaluated by three criteria; top kill, percentage of cambium killed, and inches of root kill. The top of a tree was judged dead if no green leaves were produced the year after the treatment. Root kill was evaluated by excavating the roots until live tissue was encountered, or until 12 inches of all roots had been cleared. The length of root kill was measured from the ground line to the nearest point of live tissue. By stripping the bark from the lower portion of the stem, the live cambium could be distinguished from the dead. The width of strips of dead cambium was measured and recorded as a percentage of the total circumference. Representative data on elm are shown in Table 1.

Table 1. Results of Basal Sprays on Elm With 3 Rates of Oil Carrier (Each datum is an average of 6 trials)

Herbicide	Diluent	Chem., gms.	Cambial kill, % 3 ml.	6 ml.	12ml.
		Treatment during dormancy			
D-T esters	Diesel	0.24	33	33	95
" "	"	0.12	15	22	87
" "	"	0.06	4	0	4
" "	Lt. cat.	0.12	11	66	29
" "	Hvy. cat.	0.12	11	49	37
T ester	Diesel	0.12	49	97	98
		Treatment at full leaf			
D-T esters	Diesel	0.24	34	84	100
" "	"	0.12	0	74	74
" "	"	0.06	0	37	99
" "	Lt. cat.	0.12	32	100	85
" "	Hvy. cat.	0.12	39	50	71
T ester	Diesel	0.12	77	99	99
		Treatment at leaf senescence			
D-T esters	Diesel	0.24	--	--	14
" "	"	0.12	--	18	--
" "	"	0.06	0	--	--

These experiments showed that the percentage of cambium killed was a more sensitive test than root kill. However, root kill may be a more valuable test of a desirable commercial treatment. This difference was particularly noticeable at intermediate concentrations where some cambium but no root kill was evident. Notes were taken on top-kill, but this was so highly correlated with the percentage of cambium kill that no differences were noted. Complete top-kill was achieved only with 100 percent cambium kill.

The 12 ml. per inch of circumference rate of application caused more root kill than either the 3 or 6 ml. rate. Also higher concentrations of herbicide killed more cambium and roots. The percentage of aromatics in the carrier had no relationship to the effectiveness of the treatment.

For equal concentrations, the 2, 4, 5-T ester was more effective than mixed esters. This was especially noticeable when comparing the root kills where the T ester was twice as effective as the mixture. In agreement with the 2, 4-D plus 2, 4, 5-T results, the 12 ml. per inch of circumference rate of 2, 4, 5-T was more effective than the 3 or 6 ml. rate. Treatments at the full-leaf stage were somewhat more effective than the dormant season treatment, and the treatments during leaf senescence were relatively ineffective. The cambium of some trees treated during leaf senescence was killed in a spotted pattern, suggesting penetration through cracks in the bark, but without movement in the cambium. Also formative effects were noticed the following spring on the leaves of every tree treated at this season, indicating movement in the xylem.

Of the species treated, box elder was probably most susceptible, hickory and cherry about equal to elm, and oak more resistant. The results with buckthorn (Rhamnus sp.) are of especial interest in view of proposed programs to eradicate this alternate host of crown rust. Data in Table 2 show that the plant was fairly susceptible to cambium and top kill, but no root kill was obtained with the lower rates of oil in winter, and little at full leaf. Average root kill of five to ten inches was obtained with 0.12 or 0.24 gm. of D-T esters with 12 ml. of oil.

Table 2. Results of Basal Sprays on Buckthorn With D-T Esters and Diesel Oil. (Averages of 6 trials)

Herbicide g/in.	Cambial kill, % 3 ml.	12 ml.	Root kill, inches. 3 ml.	12 ml.
	Treatment during dormancy			
0.24	93	100	0	7.0
0.12	97	100	0	4.6
0.06	0	100	0	5.0
	Treatment at full leaf			
0.24	100	100	1.1	9.2
0.12	100	100	7.5	9.8
0.06	64	99	0	2.2

Injection or Chipping Treatments

Elm was the principal species used in these experiments also, with comparisons on oak, hickory, willow, and honey locust. Treatments were made during dormancy and at bud swell, full leaf, and leaf senescence; at heights of one and three feet; at rates of 1 and 3 ml. of 4 lbs/gal. concentrate; at spacings of 4, 5, 6, 7, 8, 9 and 10 inches, and with seven chemicals.

Treatments at the full-leaf stage consistently killed the widest band of tissue. This seasonal influence was observed with the ester formulations also, although ester compounds were consistently poorer than the amines. Lateral movement of the 2, 4, 5-T formulations was usually less than that of the 2, 4-D formulations, but this difference was not as pronounced as the difference between the esters and the amines. The MCP formulations were not as effective as the 2, 4-D, but the MCP amine formulation was better than the MCP ester. The lateral movement from notches three feet above the ground line was similar to that from notches one foot above, and since the movement was approximately the same from all notches within a treatment, the more closely spaced notches gave the best control. No difference was apparent between the one and three ml. per notch injections. The root kill data were obtained from the same trees as those for lateral movement. Without exception the downward movement of the herbicide stopped at or above the root crown, or else extended at least 12 inches below the crown. The root crown therefore appears to offer an important obstruction to the downward translocation of herbicides. Thus the root kill data, which involved penetration of the root crown, are probably the best evaluation of herbicidal effectiveness of these treatments.

As noted with lateral movement, the amine formulations moved downward farther than the esters. The 2, 4-D and MCP amines were similar in their action and somewhat better than the 2, 4, 5-T formulation. Neither the 2, 4-D, MCP, or 2, 4, 5-T ester formulations showed appreciable movement into the roots. The downward movement from applications made at the three foot level was usually less than the distance to the root crown in all seasons. Treatments applied during the full-leaf stage gave consistently more root kill than treatments at other seasons. Downward movement of esters applied during bud swell varied from two to eight inches and never reached the root crown area. The same treatments had a lateral movement comparable to similar treatments at other seasons. Willow and hickory were as susceptible as elm, but oak was controlled only when closely spaced notches were used. Honey locust was highly resistant. The resistance of the latter can be attributed in part to a thin bark and hard wood which made it difficult to keep the chemical in the notch.

Discussion

The trees treated by the basal stem method were more susceptible to cambium kill than to root kill. As a result, a complete ring of cambium was often killed but some cambium below the dead portion and the roots remained alive. However, no sprouts developed on any of these trees. If this had occurred at only one season, the girdling action of the chemical could explain this phenomenon, but it occurred at all seasons. Therefore, this lack of sprouting must have been partly due to inhibition of dormant buds by the herbicides. This inhibition was shown to be possible by excised willow twig experiments, where 2, 4-D and 2, 4, 5-T inhibited the development of dormant buds but produced no evident injury. This explanation agrees with the observations of others that dormant buds are inhibited by 2, 4-D.

The superiority shown by 2, 4, 5-T ester, when applied to elm by the basal stem method, can not be attributed

to bud inhibition alone. In experiments with excised willow twigs both 2, 4-D and 2, 4, 5-T acids inhibited the development of dormant buds and, using the injection method 2, 4-D amine and ester both inhibited sprouting on elm. Thus, the increased effectiveness of 2, 4, 5-T must be due to penetration, translocation, reaction, or some related phenomenon.

When using the basal stem method the higher rate of application, 12 ml. per inch of circumference, proved more effective than the lower rates. This has been explained by various workers as being due to flow of the herbicide down the stem into the root collar zone. These observations are corroborated by both the excised twig and injection experiments, which showed that downward movement of the herbicides was much less than upward movement. This being true, a herbicide applied at the ground line would be in a more advantageous position because the critical distance to the root collar zone would be shortened. This is especially true for trees such as elm which sprout from the crown but not from the roots.

It is difficult to explain why treatments at full leaf were better than at other seasons. However, it is known that herbicides move with the sugar in the phloem, and at full leaf or shortly thereafter the downward movement of sugars in the phloem should be greater than at other seasons of the year. Also, the cambium is growing actively at this season.

The amine formulations applied by injection exhibited more downward movement than similar ester formulations. Since the amine formulations are water soluble and the esters are not, this increased downward movement may be due to differential solubility in the phloem. It has been shown, also, that rapidly toxic formulations are not translocated in the phloem. The less toxic 2, 4-D amine would thus be favored.

Summary

Both a high rate of application and a high concentration of chemical increased the effectiveness of basal sprays on woody plants. Twelve ml/ in. of 4 to 8% 2, 4, 5-T ester was the most effective treatment on elm, and full leaf in late May a somewhat better time to spray than during dormancy. Root kills were moderate at best but adequate for species like elm which sprout only from the crown. Sprouting was inhibited in all of the better treatments, even when the crown area was not killed.

Buckthorn appears to be susceptible to basal spray treatments, either in dormancy or full leaf.

Injection of 1 ml. of 2, 4-D amine, 4 lbs/gal., into chips or notches spaced about five inches apart around the base of the trees was effective on elm, box elder, and hickory, and less effective on oak and honey locust. Amines were much better than esters and the 2, 4-D amine was better than the others used. Only treatments at full leaf gave satisfactory kills. The chipping method is economical of chemical and with a Cornell tree tool should be a practicable method of killing trees. A short effective season that conflicts with other farm work is a disadvantage of the method.

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MECHANICAL CONSIDERATIONS FOR CONTROL OF WOODY PLANTS

Walter Dietsch 1/

In 1951 the Jefferson Proving Ground at Madison, Indiana was faced with a problem of clearing approximately 260 miles of roadsides, 50 miles of cyclone fence, 500 acres of firebreaks and 4,000 acres of contaminated impact area of weeds and woody vegetation.

In collaboration with Mr. William Shatwell, Fifth Army Agronomist, Dr. L. M. Stahler, USDA, Columbia, Missouri, and based on knowledge gained through research and development programs, we feel that we have developed an effective chemical vegetation control program. The mechanical considerations discussed in this paper are based on vegetation control in connection with woody plant control and are not intended to cover equipment used in the application of weedicides on cultivated crops. Any trade names of chemicals and/or equipment mentioned or illustrated do not necessarily mean indorsement by the government or Department of the Army. The progress of research and development of chemical vegetation control has been and still is in high gear; the varied types of chemicals and equipment procurable increases yearly. The development of chemicals and equipment must progress simultaneously in the quest for improved methods for the efficient control of vegetation with minimum danger to desirable vegetation and maximum operator safety.

In order that one who controls vegetation by chemical means does not become "old fashioned" overnight, he must keep abreast of the results of research and development by attending field days, conferences of this type, by reading current and authentic literature, etc.

Although not mechanical in nature, a "precontrol survey" is very essential to develop an effective chemical vegetation control program so that vegetation to be controlled and its susceptibility to various chemicals at various stages of growth, the size and location of areas to be treated, facts pertinent to neighboring areas, availability of water, etc., can be determined. Based on a survey data sheet made up in the field, a firm plan of operations-procedure can be formulated, including maps, a list of required materials and equipment, a schedule for operating, and precautions to be taken by the operator.

Prior to starting a program for chemical control, it must be recognized that the success of the program hinges not only on material and equipment, but also on operators. The results of unqualified operators can be expensive. Material may be wasted, property may be destroyed and injury to persons handling the material improperly may be hazardous. In one instance, in my experience, a soil sterilizer was washed from a crushed stone parking lot, where excessive amounts of the wrong materials were applied in dry form, to a desirable lawn area. It was necessary to repair this area by excavating the sterile loam, replacing it to grade, and sodding. Such mistakes are costly and can be avoided by close supervision or by training.

Similar errors can occur in aerial application. In one instance, locust trees were seriously damaged within the range area. This was relatively unimportant, but, on the other side of the fence, similar locust trees were all

private homes had for shade and they, likewise, were seriously damaged. This was the result of not watching the air current close enough and of having a pilot that sprayed at too high an elevation. Actual spraying was done seven miles from the damaged trees and, fortunately, no injury was found on grapes, tobacco, tomatoes, or other crops in the vicinity of the damaged trees. Incidents such as this emphasize the fact that qualified personnel to operate equipment, to realize the hazards, and to know the necessary precautions are a "must". Although these considerations are not mechanical, they are too closely related to be overlooked.

Equipment considerations at Jefferson Proving Ground hinge around types of equipment ranging from the axe to hand sprayers, mobile powered units and airships. With timing of application being important and the fact that seasonal control may be lost if equipment is deadlined for repairs, I would say service and repairs are the most important mechanical consideration. It is realized that sprayers and attachments should be procured only from reputable dealers and manufacturers capable of furnishing service and parts when needed. Following are miscellaneous comments pertinent to equipment:

1. Tanks used to carry weedicides must be strong enough to withstand the pressure of the fluid splashing around inside. There should be a large opening to facilitate cleaning of the tank. This opening should be covered and clamped securely to avoid spillage of material on operator and to avoid waste. Its size should be compatible with the discharge of the pump and the operation under consideration. The tank should be provided with a mechanical means of agitation or by means of sufficient by-pass from the pump. A good drain is also important.

2. The pump selected to do the job must be of sufficient capacity and quality to maintain adequate working pressure and flow to meet the particular conditions set by the spraying operation. An important point to consider in the case of power take-off pumps is maintaining the pressure and flow at reduced power take-off speeds when used with some tractors, where the choice of gear and speed may require operation at less than full throttle.

3. Regulating valve and pressure gauge are closely associated and should be within easy reach and sight of the operator, as should be the shut-offs and booms. Before each spraying operation, it is best to make a trial run to determine the actual output of the spraying before the herbicide is added. This takes a little time but the saving in herbicide will more than pay for a trial run to set up your calibration. Frequent checks should be made during the operation to correct adjustments to allow for wearing of nozzle orifice, especially when abrasive solutions are used.

4. Booms and/or nozzle combinations that can be made up are practically endless. Booms should be of adequate strength and properly located and hinged to prevent breakage and permit convenient transportation. Booms and connecting hoses should be of large enough diameter to prevent a significant pressure drop at the end nozzles. Due to the concentration at which many herbicides are used, special care and attention should be given to the selection and performance of the nozzles. For an efficient operation, the solution must be free of foreign material to prevent nozzles from blocking. Suction strainers, lime strainers, etc., and screens in nozzles should be washed frequently and kept in good repair.

5. Equipment maintenance: A strict cleaning program should be followed after each use of the sprayer. A thorough flushing of the tank, pumps, and boom is necessary and all nozzles and strainers should be taken off and cleaned of residue daily. The exterior of the equipment all needs a good cleaning also. For winter storage, all bare metal parts should be coated with oil and as an added precaution, pumps should be left disassembled during any long storage.

6. Application of dry materials: Where large areas are to be covered with soil sterilizer, a good fertilizer spreader with a large hopper and a shut-off to avoid leaking, as well as an agitator to evenly feed the material and break up the lumps are necessary. It is very important these be washed thoroughly to prevent rapid deterioration.

Airplane applications: For the weed and brush control on over 4,000 acres of contaminated impact areas, there were many problems. As no ground equipment is permitted in these areas, it was nevessary to take to the air. Air Force equipment available was not adaptable to brush control spraying so the job on the referenced 4,000 acres is done by contract. To date, we have specified the biplane to provide stability. These planes must be equipped with 250 or more horsepower, to have plenty of power especially where the impact areas are full of craters and an emergency land would be impossible to say nothing of the contamination. However, consideration is being given to other types of aircraft. Normally, the contractor supplies the aircraft, personnel for loading and flagging and the government supplies the material. Maps and schedules are supplied for both pilot and flagman in the field. Each field is marked by these flagmen to guide the pilot. As planes make a swath, the flagman moves over the required distance - in this case 35 feet - by measuring with his flag-pole.

During the past season these areas were sprayed with a 3/4 pound of a non-volatile ester formulation of 2, 4-D and 3/4 pound of a non-volatile ester formulation of 2, 4, 5-T with 2 gallons of diesel oil and the balance water to equal a total application of 3 gallons per acre. Results of this application were exceedingly successful.

In summary: Mechanical considerations must be compatible with available chemicals, tillage, mowing, procurement of clean seed, proper seed and mulching methods, proper timing, practical land management and purchase and fabrication of equipment, to properly fit the need.

1/ Agronomist, Jefferson Proving Ground, Madison, Indiana Presented at 11th NCWCC by W. E. Shatwell, Agronomist, Hdqts. Fifth Army.

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BRUSH CONTROL - MATERIALS AND METHODS

W. J. Coffey 1/

Depending on our point of view, plant life is classified as desirable or undesirable. Plant life which supplies man with food is given the best environment that can be made available through work and knowledge. Woody plants that contribute materials to shelter and protect man from the elements also receive a sympathetic management from him. However, weeds and unwanted woody plants interfere with man's effort to raise his average standard of living and are, therefore attacked with a concerted effort as is being done through the North Central Weed Control Conference in session here today.

Concerning ourselves with points of view for attacking unwanted woody plants, now commonly referred to broadly as "brush", the pasture and range specialist is trying to transform brush areas to grasses in order to realize more animal food; the forester is engaged in encouraging the valuable coniferous species at the expense of the "weed trees" and brush; the highway maintenance man is interested in converting the brushy vegetation on the ditches and roadsides to lower growing plant forms in the interest of driving safety and maintenance; and the utility man must keep the brush and tree limbs out of the wires so that his customers will receive electric power, telephone and telegraph service. Prior to World War II, unwanted woody growth or brush was generally controlled by cutting as the need arose. In general this cutting was almost completely with hand tools which, of course, required manpower. As long as the cost of this manpower was relatively low, control of brush by hand cutting was accepted as a good solution to a routine problem. An attractive feature of this plan, from the utilities standpoint, was that of employing off-season farm labor along the rights-of-way to do the cutting, thereby offering an opportunity to participate in the welfare of the community.

However, during and after World War II the scarcity of manpower, rising costs, mechanized farming and many other economic adjustments, familiar to all of us, generally removed casual labor from the market. This economic change caused the organization of Tree Service or Line Clearance Companies to meet the demand for brush and tree clearance work. Such organizations have overhead and many other long range operating expenses associated with their business. Naturally these factors increased the cost of brush clearance by hand cutting. For example, in 1939 an acre of brush could be hand cut with casual labor for $10-15 whereas, in 1945 the cost had increased to about $40-50. Today hand cutting costs even more.

In the competitive American tradition, people concerned with these costs started looking for a more economical method to control brush. A vigorous growing chemical industry in this country took up the challenge of competition. A period of experimental chemical brush control was required in the field laboratories between 1944 and 1947. Many companies were competing for an obviously big prize which was a new market. During this experimental period, such chemicals as sodium chlorate, borax, sodium arsenite, arsenic trioxide, calcium cyanimide, herbicidal oils, pentachlorophenol and dinitros were tried. Each was found to have some practical objection such as fire hazard, toxicity, skin irritation, etc.

At the conclusion of this period of cut and try, three products appeared to warrant extensive usage as a means for controlling brush along telephone lines with which we are primarily concerned. These were ammonium sulfamate or ammate, 2, 4-D and 2, 4, 5-T.

In 1947 ammate and 2, 4-D were used in experimental quantities on brush in Missouri, Oklahoma and Kansas. Late in 1948 a digest of these early trial use results was released by some of our experimenters. This digest included such appraisals as these:

> "Maintenance savings should average 50% or better in years following the initial chemical treatment."
>
> "Chemical control either completely kills plants and roots, or stunts growth to one-half of normal size."
>
> "2, 4-D and its derivatives are too selective and hard to control in their present state to be effective."
>
> "Ammate kills all types of brush normally found on our rights-of-way."

Actually all of the results were not this impressive nor has chemical control of brush achieved this status in the year 1954. However, when responsible people read these reports and saw first hand some of the work, a decision was made to convert brush control work to chemical methods. This conversion has been made on 10, 000 acres of brush scattered along 15, 000 miles of long distance telephone and cable lines in our particular territory. The experience gained is not local since it covers a 16 state area in the Rocky Mountain, Great Plains, Southwest and Midwest territories.

In finding our way through the brush, certain experiences have left the impression that there is a right way to go about the job of controlling brush on utility rights-of-way with chemical sprays. These experiences are being passed on to you for whatever they are worth from your viewpoint.

Whenever any job is undertaken and carried to its most successful conclusion, certain fundamentals must be established and adhered to. Business people call this making policy. If the policy is based on considerable experience, we can go in a straight line to the objective. However, on many problems there is little previous experience and people are not sure of their ground. So it was with the spraying of brush with chemicals. Today, however, we can look back and say this we know:

1. Treating mixed species of brush with chemicals on rights-of-way should be carried out on the basis of controlling growth. If, in the process of controlling the growth of brush, some species are eliminated; that is good. Unfortunately, this hard economic fact is not entirely clear to many of us yet. We are unhappy when the price of one hand cutting is spent on a spray job and the brush is not entirely eliminated.

2. Brush control requires considerably more programming and planning than it has been receiving. Anyone with plenty of money can temporarily eliminate brush on rights-of-way with chemical sprays but it takes a lot of planning to control brush growth in any manner for

less money than it costs for hand cutting.

3. A specific inventory of the brush to be sprayed is necessary. It is not sufficient to tell your labor or your contractor to spray all the brush on a line from Fargo to Minneapolis and let it go at that.

4. A set of Job Specifications is necessary for detailing the work required to spray the brush found on inventory.

5. Field inspection or supervision is required during the progress of the work.

Programming and Planning Brush Control

Cutting brush along utility rights-of-way has been practiced for more than 50 years in some cases. Cutting intervals have long been established. These intervals are 2, 3, 5 and 10 years. The interval is related to the species, rainfall, climate, etc. In general the regional cutting intervals are 5 and 10 years in the Rocky Mountain States, 3 and 5 years in the Southwest and 2 or 3 years in the Great Plains and Midwest regions. In general the program for spray treatment should be laid out along the same intervals to avoid accelerated costs. When chemicals first appeared on the market many people were sold on a program of immediately killing all the brush and forgetting the problem. They found that this took considerably more money than was anticipated.

So the first step is to prepare a long range plan and follow it. Such a plan should provide for three spray treatments. Our experience has been that after three spray treatments, very little of the original brush is left. You can be assured that this condition is not permanent.

Brush Inventory

Preliminary field surveys should be made during the growing season to obtain the following data:

1. Location and quantity of brush.
2. Growth conditions, height of brush, density.
3. The width of the right-of-way to be treated in various sections.
4. The location of access roads, ditch crossings and fence openings.
5. Location of accessible water for foliage spray.
6. What crops are grown in the area that may limit the method and time of treatment.

Job Specifications

With the inventory information a set of job specifications can be prepared that will permit an estimate of the cost of the work. The specifications are important because they are the final product of all the planning and will determine whether the results are good or bad.

For the last several years we have been using a standard set of spraying specifications based on our experience. These specifications are simple and straightforward. The specifications were prepared specifically to correct many past brush spraying errors.

Included in the specifications are 3 basic considerations for each type of spray; as follows: (a) Coverage, (b) Timing, and (c) Materials.

Under coverage and timing there are no deviations. Compromising with either is settling for less than a good job. For example, you have heard the term "foliage spraying" many times. To us this terminology is most misleading since it has been interpreted to mean spraying the foliage on brush. Our results have demonstrated that the whole plant; leaves, stems, branches, trunks, must be wet with the spray to realize the best control. Therefore, the specifications for foliage treatment state that, "Foliage spray material shall be applied to cover all the leaves and all the bark of each plant in a careful, non-wasteful manner". Similarly the specifications for basal treatment state that, "Basal spray material shall be applied to the trunk from about one foot height down to the ground line so that all the bark is completely covered around the plant. A sufficient amount of material shall be sprayed on the bark to observe a runoff onto the ground entirely around the plant base." The important thing here is to completely encircle the plant and have runoff to kill the latent, plant crowns; anything less than this will not be effective generally.

Timing of spraying work is also significant. Foliage sprays are started four weeks after the bud break and are stopped on August 15 north of Latitude 42° and at all other locations on September 1. Timing has another meaning in the control of brush with chemicals. If a sprout 18 inches high with 3 leaves on it is growing out of an old stump with a root system 10 ft. in diameter, there is little possibility of killing this structure with foliage spray. Let the brush grow larger and then treat it.

Also on the point of proper timing of foliage sprays, Dr. A. S. Crafts presented a paper at the Tenth Annual Meeting of this conference last year which included several ideas that appear to warrant our attention. Summed up in lay language the points made were that foliage sprays should be applied so that the herbicide is absorbed by the plant when it is in a normal state of growth. It was indicated that in mixed species of brush there might not be an optimum time for initial foliage spraying. There is also the question of just when normal growth processes occur again after partial damage. A plant which has been damaged badly by a foliage spray would not appear to be in shape to carry out the normal functions of growth during the following year.

Timing of dormant basal sprays is not too clear to us. However, best results have been obtained when the plants were treated between January 1 and the first signs of bud break. Here again basal treatment would not be very effective when a snow cover shields the base of the plant so that runoff is not obtained. Neither would basal treatment be effective if a heavy coat of leaves was banked around the plant to prevent runoff.

Stump treatment is performed preferably not later than 3 days after cutting.

So much for some of the aspects of timing sprays. This brings us up to the question of what materials to use and in what proportions.

Materials

The following observations are not intended to reflect discredit on any product of any company. It is simply our view that from an economic standpoint some materials are better than others under a given set of conditions.

Mixed species of brush are given an initial foliage spray using one gallon of low volatile 2, 4-D and 2, 4, 5-T

(2 lbs. acid equivalent per gallon of each) mixed with 100 gallons of water. The amount of spray required will vary with the density of the brush from 150-200 gallons per acre. Where crop damage is a consideration, the brush is given an initial foliage spray using 75 lbs. of ammate per 100 gallons of water. With this material 300 to 350 gallons per acre have given best results. A non-soap type spreader-sticker is used at the rate of 5 ounces per 100 gallons of ammate solution.

What material should be used for the second spray treatment depends entirely on local conditions such as percent initial kill, species left, accessibility, etc. However, in most cases a second foliage spray is the proper treatment. Again if crop damage is not a consideration the brush should be foliage sprayed the second time with a 50-50 mixture of 2, 4-D and 2, 4, 5-T in the proportion of 1 gallon to 100 gallons of water. Where ammate was used initially the same solution is used for the second foliage spray.

After two foliage sprays the deficiencies of application have been eliminated. We must face the fact that the man on the end of a high pressure spray gun does not do a thorough job the first time. This feature of the work is not due to indifference; the workman has to produce and with overhead, carrying charges, etc. he must keep moving on down the line to make a living. This is simply an economic compromise that all of us know about.

After the second foliage spray with 2, 4-D and 2, 4, 5-T we have reached the stage where the experts start to work. As far as I know they are still working on ways and means to kill oak, hickory, ash and a few other hard to kill species with foliage treatment.

In many cases a third foliage spray has been applied using 1 gallon of 2, 4, 5-T to each 100 gallons of water. Some additional kill and considerable control have been realized. Our people are about convinced that a better approach would be to basal treat the remaining scattered brush on a sort of routine maintenance basis whenever they happen to be working in the vicinity. For basal treatment one quart of 2, 4, 5-T is used in 10 quarts of oil where hard to kill species are involved.

Following the second foliage spray with ammate, we have been applying a third one. Experience has been that very little brush survives three ammate foliage sprays.

Field Inspection and Supervision of Spraying Work

The greater portion of chemical spray work for utilities is being done by private contractors or Service Companies under competitive bid type contracts. These contracts may be one of the following types:

(a) the "hourly unit rate" type for labor and equipment plus material.

(b) "Gallonage rate" type for applying a gallon of solution.

(c) "Lump sum" type for treatment of the overall section including material.

Uniform high quality results can be secured only by maintaining rigid high standards regarding the application of the spray material. Care in measuring chemicals, proper mixing of solutions, thorough coverage and expert handling of the spray nozzles. The field inspector of the utility is put on the job to see that the work in the specifications is carried out. This is about the only recourse available since the contractor is paid in full for his work when the job is completed. No one knows what will be bought with this money until the next growing season. Even then appraisal is difficult.

Results

The final yardstick applied to brush control is the measurement of cost. Of course, there are many ways to measure cost. If costs are measured for hand cutting versus spraying over a 1 to 4 year period, it will be found generally that hand cutting is cheaper. However, if a 6-10 year base is used, costs will favor spraying.

You are probably aware that telephone people are quite statistical minded. It is the nature of their business. To follow this new idea of brush control, a number of very complete records have been kept. These records include such facts as when the work was done, the exact location, how many acres of brush were treated, its average height, what material was used, the solution applied, the gallons per acre, the cost per acre for material and for labor.

Following the brush work on a specific line in this manner for a period of 6 to 10 years provides information that permits cost evaluation of the work on a long range basis. Several representative cases of this type follow.

On a line in north central Missouri the two year cycle hand cutting of brush was discontinued in 1945. Foliage sprays of ammate were applied in 1947, 1948 and 1950. If we assume that the cutting costs every 2 years remained the same as in 1945, about $6600 would have been spent for hand cutting. The three ammate sprays cost $4, 800. This is a reduction of about 28 per cent over the cost of hand cutting. No money has been spent on the brush during the last 4 years.

On a line in southern Illinois two year cycle hand cutting of brush was discontinued in 1946. The brush was foliage sprayed with ammate in 1947; about one third of the remaining brush was foliage sprayed with ammate again in 1950 while the other two-thirds was cut and stump treated with 2, 4-D and 2, 4, 5-T; a third foliage spray with 2, 4-D and 2, 4, 5-T was applied in 1951; and, a fourth foliage spray with 2, 4-D and 2, 4, 5-T was applied in 1953. Hand cutting on a two year cycle during this period would have cost $9600 using 1946 prices. All of the spraying work cost $3600. This is a reduction of 63 per cent in cost over hand cutting.

Two year cycle hand cutting on a third line in southern Illinois was discontinued in 1948. Half of the brush was foliage sprayed initially with 2, 4-D and 2, 4, 5-T in 1951 and the other half in 1952. The second foliage spray was applied to all of the brush in 1953. A third foliage spray is in the program for 1955. The cost of all of the spraying will amount to $9100. Hand cutting at 1946 prices would have cost $19, 500. Over a 7 year period this is a reduction in cost of about 55 per cent.

Summary

Briefly, let us review what we have said about the materials and methods for chemical treatment of brush along utility rights-of-way.

1. We should not lose sight of our problem today in chemical brush control which is not simply one of killing or controlling any given woody plant, but of accomplishing it economically.

2. Set up a long range plan and follow it.

3. Prepare a good inventory of the job.

4. Cover the work with a detailed set of specifications that include the materials to be used, the timing of the work and the plant spraying methods.

5. Proivde a business like check of the work while it is in progress.

6. Measure the results of your effort.

1/ Long Lines Dept., American Telephone and Telegraph Co., Kansas City, Missouri.

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POSSIBILITIES OF AERIAL SPRAYING IN FOREST MANAGEMENT IN THE LAKE STATES

Eugene I. Roe 1/

Four years ago, aerial application of chemicals to control brush and other undesirable woody plants was a practice little known to most foresters, at least in the Lake States. Naturally, we had heard something about such spraying for range improvement in the southwest, but to most of us, the results of ground applications of 2, 4-D were astonishing enough to satisfy our need for technological progress, we thought, for a long time.

In the summer of 1951 a few of us got together with men representing the airplane sprayers and the herbicide manufacturers and planned some cooperative small-scale tests of this new tool in Minnesota. The outcome was a total of twenty acres sprayed from the air in the latter part of August of that year, part of it lowland brush and part upland species. 2/ A kill of 70 to 90 percent of the brush was obtained in each area from 1 to 4 gallons of solution per acre. The results were thus comparable to ground spraying using 80 to 100 gallons of solution. Resprouting occurred but was no greater than that following any foliage spraying done that late in the growing season.

As word got around about these small trials, a great deal of interest in brush control by aerial spraying was aroused among foresters. Evidence of this is the increasing amount of forest land which is being sprayed for this purpose. In the summer of 1952, some 620 acres were treated in Michigan, and in 1953 almost eleven hundred additional acres were covered, partly in Michigan and partly in Minnesota. This past summer some 5, 400 acres throughout the three Lake States were sprayed from the air. Agencies doing this work include: The National Forests in Michigan, Wisconsin, and Minnesota; the Game Division of the Michigan Conservation Department; the Northwest Paper Company; the Minnesota Division of Forestry; and the North Star Timber Company.

Since research in aerial spraying has not yet been able to solve all the problems, many of these jobs in the Lake States have been done on a trial-and-error basis with the thought that they will help supply some of the information needed in this field. The interested agencies feel that since ground spraying is effective, aerial application should also be of benefit. Moreover, they believe that since such jobs are much cheaper than those done by hand labor, they can afford to spray a second time if the first operation does not yield the desired result.

Fortunately, on most of the areas sprayed to date, the results have been encouraging. A good example is the first aerial spraying done in Lower Michigan. Two 4-acre plots of low-grade oaks up to 50 feet in height and a foot in diameter were sprayed on the Manistee National Forest in late August, 1952, using one and two pounds of 2, 4, 5-T respectively in five gallons of solution per acre. An examination this past summer, two years later, showed that 90 percent of these trees were defoliated. The remainder had live foliage on the lower branches but this appeared to be dying. Similar results are also shown by a 500-acre tract of scrubby oaks on the Huron National Forest which was sprayed in mid-August, 1953, with one pound of 2, 4, 5-T in two and a half gallons of solution per acre, (1).

Since spraying of this kind, however, can conceivably result in costly failures, it is only good business for any agency contemplating such work to make sure it has all the information available on the species it is desired to control. For example, it would seem better not to spray large areas of aspen until more is learned about the reasons for the erratic results which are being obtained with this important species.

Although there is considerable room for improvement in application techniques, such as flight patterns, time schedules, area marking, etc., we have made a lot of progress in adapting this modern method of applying herbicides to forest management. Because of the generally larger vegetation involved and the consequently greater height at which the aircraft must fly, aerial spraying in our work will likely never do quite as uniform a job as for agricultural crops. However, this is not necessary, for in most jobs where herbicides can be used we are more interested in tipping the ecological balance just enough to favor the crop trees than we are in complete kill of their competitors. In other words, if we can give the undesirable species enough of a setback so that the favored trees will win out in the competition for dominance, we will usually be satisfied. Consequently some of the jobs that will be acceptable to us may look rather poor to the layman. Such lower standards will, of course, be accompanied by lower costs.

Thus far we have dealt in generalities. Let us now take a look at the various jobs for which foresters are using aerial spraying in the Lake States and discuss thier possibilities as an aid to better forestry. The most important of these jobs so far has been plantation release. Others are the preparation of brushy land for planting; killing brush and unwanted overtopping hardwoods to encourage natural reproduction of conifers (this both in swamps and on highland); and the opening up of low-grade aspen stands to improve the range of game birds and animals. Of potential importance is spraying in conjunction with the under-planting of low-quality aspen with red pine.

Plantation Release

As many of you know, the planting of forest land denuded by logging, fires, or unwise farming or a combination of these has been of very great importance in

the Lake States. Beginning on an appreciable scale in the 1920's, the planting of the conifers, pine and spruce was later given a great impetus by the C.C.C. which lasted until the war years. Since that time a much smaller amount of planting is being done. It is still an important activity, and if some of the things we are now testing are successful, it will likely become of even greater importance. All told, some 1,920,000 acres have been planted in the Lake States. Unfortunately about one-fourth of this area has been lost, partly because of fire and insects, but mainly, due to lack of plantation care.

Contrary to common belief, plantation establishment consists of a lot more than putting the trees in the ground. Forest plantations, like the common farm crops, also have weed enemies, and failure to control them is just as serious as it is in the cornfield. Neglect of these weeds can result in the complete loss of the planted conifers or, at best, in a great reduction in their growth. On most areas, therefore, planting is only the first step in plantation establishment. The second is control of the weeds, which are composed of some herbs, but mainly shrubs and the suckers or sprouts of such broadleaf trees as aspen, birch, and oak. This control is commonly known to the forester as plantation release.

Plantation release is of two general types, low release and high release, depending on the size of the vegetation interfering with the planted trees. Low release is commonly done within 3 to 5 years after planting. If the job is well done, the conifers will grow rapidly and get ahead of the brush so that the more expensive high release will not be needed. Most of the large area now needing high release is the direct result of the insufficient amount of labor and funds available to do this work during the war and following years.

Up until a couple of years ago, when the possibilities of using aerial spraying for such work became evident, practically all plantation release was done with hand labor. Power saws had come into limited use in high release, but in the main, hand cutting with axes or other edged tools was the rule. In addition to being time consuming, hand work is very costly, varying from $13.00 to $25.00 per acre depending on the degree of cover removed. The discovery that foliage spraying with chemicals could be used effectively to kill back the brush without harming the planted trees was, therefore, of great interest to those responsible for plantation care. However, due either to their large size, inaccessibility, or rough terrain, it was impracticable to spray-release many plantations from the ground. Power spraying was, of course, much more rapid but when one considered the investment needed in equipment the cost was often about as high as that of hand spraying.

However, the use of aircraft to apply the herbicides needed for spray-release has put an entirely new face on plantation release. Not only can large areas of plantations be released in a very short period of time, but also this release can be done at a cost lower than we would have believed possible a few years ago. For example, during the nine-day period, August 9 to 17, 1954, the Lower Michigan National Forest sprayed some 2,000 acres of pine plantations overtopped by a growth of scrubby oak at a cost of less than $2.50 per acre. No results are, of course, available from this job although by the end of August the oak leaves were brown enough to show that coverage had been good. Release by hand methods would have required in the neighborhood of 2500 man days of labor and would have cost about $13.00 per acre.

With such savings possible, it is easy to understand why the men in charge of administering forest lands are willing to spray large areas even though we do not have the final answer on the optimum amount of chemical and volumes of solution per acre needed to control all of the common competitors. They feel that although they may not get complete kill of the competing trees, enough release will be given that the plantations will be greatly benefited.

Because it is needed more urgently, almost all spray release being done with aircraft to date is high release. However, low release can also be done effectively from the air. This is shown by a 70-acre plantation of jack pine overtopped by willow which the Minnesota Division of Forestry sprayed last summer. Kill of the willow in late August averaged 80 percent with little injury to the pine.

Because of the large amount of plantation release needed and the high cost of hand work, it is not surprising to find that such work was the main objective on 5200 acres of the 7100 acres which have been sprayed from the air for brush control in the Lake States through 1954. Some idea as to the future possibilities of aerial spraying in this field may be had from the estimate that there are about 213,000 acres of plantations in the Lake States needing release, much of which could be done with chemicals applied from aircraft. And this, of course, does not include the release of the large areas which are yet to be planted.

Preparation Of Brushy Sites For Planting

A second promising field for the aerial spraying of herbicides and one in which some work is being done, is the preparation of brushy land for planting. It has been found that if brush is killed during mid-summer when its food reserves are at the lowest level, resprouting will be kept at a minimum. Plantations put in in the following fall or spring after such brush treatment, which is called ground preparation or pre-release, can, therefore, be brought through with only one release operation after planting compared to the two or more releases needed where no effort is made to combat the brush.

Heretofore, ground preparation has been done by going over the land thoroughly with a heavy disk. Consequently, rough or rocky upland sites could not be treated nor could the lowland soils. Furthermore, disking is slow and expensive, costing on the average about $15.00 per acre. Since aerial spraying is faster and considerably cheaper than disking it would seem to offer an excellent substitute for the latter in the pre-release of the larger areas of brushy upland. Although we do not yet have any final results from this kind of work (a 20-acre tract was sprayed on the Superior National Forest last July), we have obtained successful pre-release from ground spraying. Hence, there seems no good reason why aerial application would not be just about as effective.

Being unaffected by ground surface conditions, aerial spraying also promises to extend ground preparation to rocky and boggy lands where disking is out of the question. For example, we have in the Lake States about two and a half million acres of peat land on which the original forest of black spruce, tamarack, and other swamp conifers has been destroyed by logging and fire, leaving only alder, willow, and other worthless brush. If these conifers could be re-established, these lands would again produce much of the pulpwood needed by our great pulp and paper industry. Hitherto, the lowlands did not appear to be economically plantable, mainly because there was no reasonably cheap method of getting rid of the brush. How-

ever, judging from our success in killing lowland brush from the air in 1951 near Effie, Minnesota, aerial spraying may well change this situation.

At the present time, the control of the brush is at a somewhat more advanced stage of development than is the planting. In order to learn more about the planting of swamps, the Lake States Forest Experiment Station is cooperating with the Minnesota Division of Forestry in a study involving about 160 acres of wet land. These areas were sprayed from the air last summer, killing back the alder and willow, and were planted this fall to black spruce. Additional spruce will be planted next spring so that we can evaluate the relative merits of spring versus fall planting of brushy lowland following spraying.

Conversion of Low-Grade Aspen to Conifers

Another field involving planting after spraying herbicides is the conversion planting of low-grade aspen stands to conifers. About three million acres of poor-site aspen in the Lake States should be converted to pine forest and thereby enabled to produce a considerably higher return than at present.

Hand cutting of the aspen is prohibitive and disking is not feasible in most areas because of the size of the trees. If we can learn how to kill this species with foliage sprays, considerable progress could be made in getting these lands back into pine. Good kill has been obtained by spraying aspen in Lower Michigan, but results in Minnesota have been rather poor. Once a dependable technique is worked out, the most likely approach would be to underplant with red pine and a year or two later to spray the aspen overstory from the air with herbicides.

Encouraging Conifer Reproduction on Brushy Land

Thus far all of the jobs discussed involve planting or what is sometimes called artificial restocking. Another phase of forest management in which aerial spraying with herbicides seems to have promise is the restocking of stands, particularly conifers, by means of natural reproduction. In Minnesota and elsewhere in the Lake States large areas have light stands of scattered conifers - spruce andf fir - in which the ground is heavily shaded by dense brush or by poor-quality hardwoods which may be mixed with the conifers. Because of the density of the brush or the trees, the few seedlings of black spruce, white spruce, or balsam fir which follow the periodic crops of seed produced by the older conifers, last for a few years and are then shaded out. Opening up the brush or the hardwoods by hand labor in order to give the conifer seedlings a chance to develop would be prohibitive in cost. Frilling followed by treatment with 2, 4, 5-T could be used on the hardwoods, but not on the dense brush which most of these stands contain. It would thus do only a partial job and moreover, is slow and fairly costly.

The promising results shown in plantation release operations have naturally led to trials of aerial spraying as a means of encouraging the successful natural invasion of conifers in these brushy lands. So far most of this work is being done in Minnesota and involves two main types of sites, brushy lowland with a scattered growth of black spruce and tamarack and the so-called "birch belt" of the North Shore of Lake Superior.

The work in the "birch belt" is of especial interest, for the reproduction problem, the most difficult known in Minnesota, involves about a half-million acres in that state and an apparently larger area north and east of Lake Superior in Canada. The stands typically consist of paper birch, most of it large culls, with a few scattered white spruce and balsam fir. There is a dense understory of mountain maple, hazel, and alder, in places 15 to 20 feet high. Although this type of stand grows on some of the best forest land in the state, it actually yields but a small fraction of its potential production because of the low proportion of conifers. Once the large spruce and balsam are cut, the situation becomes hopeless since there are few conifers to take their place.

Because of the importance of this problem on company-owned lands, the North Star Timber Company sprayed 140 acres of these brushy stands in early July, 1954. Although it is too early to evaluate the several treatments under test, most of the large birch and much of the brush were killed, thus opening up the overstory and giving the seedlings considerable light. And this from as little as one pound of acid applied in two gallons of solution per acre! The "birch belt" brush is consequently beginning to look like a less formidable obstacle to good silviculture in that part of Minnesota.

Creating Conditions Favorable for Wildlife

A field allied to forest management and one which is often intimately associated with it is wildlife management. Here too aerial spraying is being tested and seems to have possibilities. The Michigan Conservation Department has sprayed over 700 acres of practically worthless aspen in Lower Michigan and in the Upper Peninsula with the hope of killing off these trees and opening up the areas to make good cover conditions for sharptail and ruffed grouse. On the first of these tracts, 600 acres sprayed in 1952 in cooperation with the Dow Chemical Company, the aspen was killed, but suckered heavily the following year. Since the object here is to get rid of tree growth, about 400 acres of this tract was resprayed the past summer. A good kill of the two year old suckers is reported. Along with this work, the Department has also sprayed 225 acres of off-site aspen in various deer yards, the purpose being to encourage these suckers which are a valuable deer food. The later work was also done last summer, (2).

Discussion

So far the discussion has emphasized the advantages of aerial spraying - its speed, its low cost, and its possibilities on areas with difficult surface conditions. Aerial spraying also has a few disadvantages. The first of these is the drift problem. Because of this, spraying has to be restricted to weather which is practically calm and to tracts where there is no chance of injuring desirable stands or crops on adjacent land. In areas where forest land is a checkerboard of diverse ownership, it may, therefore, be impossible to use this approach.

Another disadvantage is the fact that spraying with conventional aircraft is not feasible on tracts of irregular outline.

Third, aerial spraying in such jobs as high plantation release may give more kill of the overstory than may be necessary or even desirable. In hand release one can, of course, spare any hardwoods which are not actually interfering with the planted trees, but this is not true in aerial spraying.

Since such hardwoods may serve as trainers for nearby conifers and further can supply an intermediate crop of wood, their complete elimination may not be desirable. This is something the manager of the plantation will have to decide for himself.

All things considered, however, I believe I am not over-optimistic in saying that the aerial application of herbicides has great possibilities as an aid to better forest management. This seems true not only in the Lake States, but also in the several other forest regions. Of course, some "bugs" still need to be worked out before this promising technique can be depended upon to give the results of which it seems capable. However, these are not so troublesome that they seriously impede the success of spraying. It, therefore, should not be necessary to delay spraying until those problems are solved, except perhaps in the case of erratic species like aspen, for even though kill of the undesirable brush and trees may not be complete, enough benefit will result to make the job worthwhile. Although it is foolhardy to make predictions in an atomic age such as this, it seems likely that in a few years the use of hand or other ground methods in such jobs as plantation release, preparing brushy sites for planting, and opening up brush to encourage natural reproduction, will be largely replaced by aerial spraying with herbicides.

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1/ Lake States Forest Experiment Station, St. Paul 1, Minn.

2/ Cooperators were Lake States Forest Experiment Station; Division of Forestry, Minnesota Conservation Dept.; School of Forestry, Univ. of Minn.; Minnesota and Ontario Paper Co.; Northwest Paper Co.; Minnesota Airplane Sprayers Assoc.; and Dow Chemical Co.

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THE CONTROL OF LOCAL SPREAD OF OAK WILT AND CERTAIN OTHER TREE DISEASES WITH HERBICIDES

J. E. Kuntz, C. R. Drake, and A. J. Riker 1/

Chemical herbicides have proved a valuable silvicultural tool. They also show considerable promise in the indirect control of certain forest tree diseases. Plant disease controls are directed mainly at the prevention of initial infection rather than at subsequent cure. Protection of the forest stand rather than protection of the individual tree usually determines the forester's choice of control procedures. Direct measures such as the use of fungicides, insecticides, and specialized cultural techniques which have been employed so effectively for horticultural crops have limited application in forestry practice.

Several rust diseases kill forest trees or limit their utility. By eradicating nearby alternate hosts which are necessary for the completion of the life cycle of the respective fungus pathogens, the more valuable trees are protected from infection. Effective disease control programs based on this principle include the protection of 5-needled pines from white pine blister rust by Ribes eradication and the protection of cultivated and ornamental apples from cedar apple rust by eliminating the red cedars. In the same way, barberry eradication reduces early stem rust infection of cereal crops. Elimination of buckthorn reduces crown rust infection of oats. Recently, the use of chemical herbicides has replaced laborious and costly hand eradication methods.

Many plant viruses and/or their insect vectors increase and overwinter on weed hosts. Removal of these weed hosts reduces the reservoir of inoculum and delays or limits new infections. Peaches, for example, have been protected from the X-disease by complete eradication of chokecherry within 500 feet of peach orchards. As a general precaution, wild species of Prunus are removed from the immediate vicinity of stone fruit nurseries.

A more direct approach is the attempt to eradicate parasitic mistletoes from infected trees by the use of selective herbicides.

The purpose of the present investigation is to determine whether silvicides might aid in preventing the spread of oak wilt. This fungus disease spreads in at least two different ways. In one case, it "jumps" considerable distances--anywhere from a few hundred yards to more than a mile to previously healthy trees. Various carriers or vectors are suspected, including birds, rodents, and insects. From recent studies, it appears that the mats of the oak wilt fungus which grow and sporulate between the bark and wood of wilting oaks may provide an abundant source of inoculum to insect vectors implicated in long distance spread. Whether herbicidal treatment of wilting oaks will prevent mat formation or sporulation by hastening the death, decortication and desiccation of the tree is being tested. So far, fewer fungus mats have developed on infected trees poisoned with sodium arsenite or a mixture of 2, 4-D and 2, 4, 5-T than on untreated trees. Eradication of the fungus, however, seems unlikely because of the poor distribution of materials within wilting trees and of the tolerance of fungi for common herbicides.

A second type of oak wilt spread is the progressive movement from diseased to adjacent healthy trees in local areas. This radial spread outward from an infection center usually involves only one or two "tree depths" per season although as many as five trees along 55 feet of an oak fencerow have been infected in one year. Washing and digging out tree root systems have disclosed numerous natural root grafts between individuals of a species of the red oak group, few between members of the white oak group, and only one between trees of these two groups. Normally, such unions may benefit the tree community. But when oak wilt invades a dense stand, these grafts provide direct "pipelines" for infection from tree to tree.

Although no method is known for controlling the local spread of oak wilt under all circumstances, certain experimental procedures have proved effective in stands of northern pin oak, Quercus ellipsoidalis, in central Wisconsin. For lawn and park areas, where each individual tree has considerable aesthetic value, the mechanical severing of all roots and root connections between wilting and adjacent healthy trees has reduced or prevented further local spread. By the time an infected tree develops initial wilt symptoms, the fungus may have passed already into adjacent "healthy" trees through grafted roots. Thus, 2 or 3 successive cuts or trenches often are nec-

essary so as to isolate these infected "healthy" trees.

This early movement of the fungus from a wilting tree into adjacent healthy trees may account also for the variable results obtained from poisoning the infected tree itself even at the onset of foliage wilt. In a few cases where adjacent trees also have been injured severely or killed by translocation of the poison through common root grafts, no additional trees have become infected.

In woodland areas where individual trees are of relatively low value, poisoning healthy trees bordering a wilt-infected pocket has prevented further local spread. Root kill is essential. Cut stumps and girdled or inadequately poisoned trees sprout prolifically. Roots of such trees or stumps may live for years, especially when these roots are "adopted" by being grafted to the roots of adjacent living trees. The fungus may persist in the roots of wilt-killed trees or of their cut stumps for more than a year. Hence, in Wisconsin, the eradication of all dead and wilting oaks by itself has failed to prevent further tree-to-tree spread.

In experimental plots established in 1947, no new wilt has appeared across 35 to 50 foot "barriers" of oaks poisoned with sodium arsenite (61% solution). The solution was applied into holes spaced every 3 or 4 inches around the root collar or holes in the main buttress roots. Treatments made during March and April gave poor kill with limited distribution of the poison within the tree. No translocations to adjacent trees occurred. Trunk suckering and basal sprouting were common. However, early and midsummer treatments gave excellent and rapid kill. The poison moved extensively throughout the crown, and frequently through root grafts into adjacent oaks as far as 48 feet away.

Downward movement of sodium arsenite into roots was limited except where roots were grafted to those of adjacent trees. In grafted roots, the poison moved downward for long distances, through the root graft, and thence through the root of the other tree. Trunk girdling at the time of poisoning increased the number of translocations. Suckering and sprouting occurred infrequently. Bark loosened rapidly.

Since sodium arsenite is extremely poisonous, suitable precautions are essential to prevent wildlife, cattle and irresponsible persons from reaching it.

The effectiveness has been tested of several other less toxic herbicides. While generally accepted basal and frill treatments using 2, 4, 5-T, mixtures of 2, 4-D and 2, 4, 5-T, and ammate have given good top kill in most cases, they allowed variable sprouting from surviving roots and root collars. Already some sprouts and a few trees beyond the barrier have become infected with oak wilt.

3-(p-chlorophenyl)-1, 1-dimethylurea (CMU), applied in 1952 to ground strips either as water suspensions or as rapidly disintegrating pellets at 50, 100, and 200 pounds per acre, killed or severely injured most oaks within 25 feet of the treated strip. Lower rates when applied on top of accumulated litter and duff caused much less injury to woodland oaks. In contrast, oaks bordering repeatedly rototilled firelanes (with little accumulated humus) treated with CMU at 20 pounds per acre showed considerable injury.

Response to CMU was slow. Trees a short distance from the treated strips commonly showed injury before trees within the area. White and bur oaks showed initial injury to most poisons only on scattered branches. Many trees died the first season. Others, however, survived and refoliated the following spring. Their foliage soon turned brown and died. Suckers and sprouts developed weakly from a few injured trees, but died in 1953 or 1954. The majority of roots were killed on trees with above ground parts dead. Severely injured trees possessed dying roots.

While no wholly satisfactory method for all circumstances has been devised, a barrier of poisoned trees has effectively stopped the tree-to-tree spread of oak wilt.

The work thus far reported encourages further study of silvicides for this and related problems.

1/ Dept. of Plant Pathology, Univ. of Wisconsin, Madison, Wisc., in cooperation with the Wisconsin Conservation Department, the National Oak Wilt Research Committee, the Atomic Energy Commission, and the Nekoosa Edwards Paper Company.

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INTERIM REPORT ON UREA HERBICIDES FOR BRUSH CONTROL IN OKLAHOMA 1/

Harry M. Elwell 2/

Many new herbicides have been offered to research workers and the general public during the past ten years. These are of two general types: the selective and non-selective. Three substituted ureas belonging to the latter type have been tested recently on oaks and other woody plants at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma. This report records the progress that has been made in utilizing these materials for the control of brush and trees.

Herbicides Used. 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU), 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea (DCMU), and 3-(phenyl)-1, 1-dimethylurea (PDU) were tested. These were used mainly in the powder form which was 80 percent active. CMU was also applied in pellet form that was 10 and 25 percent active.

Methods of Applications. CMU was first applied in April of 1951, in axed incisions on oak trees. Both dry powder and a mixture containing 1 to 2 pounds of 80 percent active powder per gallon of water were applied. CMU was also applied in foliage sprays, basal bark treatments, and soil applications. In these tests, it was applied in a suspension of water and diesel oil, in the form of dry powder, and in pellets. The main treatments from 1952 to 1954 were on small plots covered mostly with dense stands of oak brush and small trees. A number of other woody plants were also present and several species were individually treated. CMU at rates of 1/16, 1/8, 1/4, and 1/2 pound of 80 percent active powder per gallon of water was used. Each amount was applied with a knap-

sack sprayer, placing a band about 4 inches wide on the surface of the soil around the individual plants. The respective rates used in this method of application were about 4.5, 7.5, 15, and 30 pounds per acre. Applications were made during the months of January, February, March, April, and July of 1952, 1953, and 1954.

During February, 1954, CMU, DCMU, and PDU were each mixed with superphosphate and handbroadcast on plots having a dense cover of undisturbed oak brush and small trees. CMU and PDU were each applied at rates of 7.5, 15, and 30 pounds of 80 percent active powder per acre. The rates for DCMU were 7.5 and 15 pounds of 80 percent active powder per acre. Each amount was mixed with sufficient fertilizer to equal an application of 300 pounds per acre.

In January, 1954, a study was made, using various amounts of CMU on a dense regrowth of brush under an electric transmission line. This area had been cleared of brush four years before and the new growth ranged in height from 3 to 6 feet. A power sprayer was used to apply the material on the surface of the soil. In addition, pellets were handbroadcast on an area 325 feet long and 30 feet wide under the line.

Soil and Climatic Conditions. All of the urea herbicides used were applied either on fine sand or sandy loam soil. The surface and subsoil moisture has been generally deficient due to drought through the periods tested.

Results

Effects of Urea Herbicides on Plants

In general, the best kills with CMU were from applications suspended in water and applied on the surface of the soil around each plant (Table 1). The other urea herbicides, DCMU and PDU, however, were about as effective.

Dormant treatments did not show signs of toxicity until the new leaves approached full size. Applications made during the growing season usually affected the plant within about one month. Symptoms observed were necrosis of leaves from outer edge to veins, followed by progressive defoliation and dying of the cambium and phloem. The above-ground part of severely affected plants died and became brittle within four to five months after the first appearance of symptoms.

Trees and Brush. The oak species, red cedar, hackberry, chittumwood, western crab apple, buckbrush, sumac, and sand plum were successfully killed with about 7.5 pounds of CMU per acre. Good kills were obtained with about 15 pounds per acre on elm, dogwood, and redbud. The same rate produced a high percentage of kill on persimmon and Osage orange. However, there has been some root sprouting from the latter affected plants. It was observed that the persimmon, elm, redbud, and dogwood occasionally did not die until the second year after treatment. The most susceptible of the species studied was the wild grape and the most resistant was greenbrier. In other tests, however, poor kills were obtained where the pellets and dry powder were applied on the surface of soil and in the soil at depths of 2 to 8 inches.

Table 1. Effectiveness of Soil Applications of CMU at Various Rates on Control of Brush in Oklahoma

Species Name 1/		Percent Kill (Chem. lb/gal Water)			
Common	Scientific	1/16	1/8	1/4	1/2
White and Post Oak	(Quercus alba L. and Q. stellata Wang)	10	100	100	100
Blackjack Oak	(Quercus marilandica Muench)	10	100	100	100
Chinquapin Oak	(Quercus prinoides Wild)	0	100	100	100
Red Cedar	(Juniperus virginiana L.)	-	100	100	-
Elms	(Ulmus americana L.)	-	20	100	100
Persimmon	(Diospyros virginiana L.)	-	0	90	-
Hackberry	(Celtus occidentalis crassifolia)	10	100	100	-
Chittumwood	(Bumelis Lanuginosa/Michx./Persoon)	10	100	100	-
Osage orange	(Toylon pomiferum Rafn.)	-	0	80	-
Western crab apple	(Malus ioensis palmeri Rhed.)	-	100	100	-
Willow	(Salix nigra Marsh spp.)	-	50	100	-
Greenbrier	(Smilax spp.)	0	0	20	-
Wild Grape	(Vitis spp.)	100	100	100	-
Buckbrush	(Symphoricarpos orbiculatus Moench.)	0	100	100	-
Dogwood	(Cornus asperifolia Mich.)	0	0	100	-
Redbud	(Cercis canadensis L.)	0	0	100	-
Sumac	(Rhus copallina L.)	0	100	100	-
Sand Plum	(Prunus angustifolia Marsh.)	0	100	100	-

1/ Applications with 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU) were made on oaks at various periods during the years 1952, 1953, and 1954. Treatments of other species were in 1953 and 1954. Comparable results were obtained each year.

2/ The 80 percent active powder at various rates was mixed with water and handsprayed in a band about 4 inches wide on the surface of the soil around the base of each plant. The respective rates used were about 4.5, 7.5, 15, and 30 pounds per acre. Final observations were made in September, 1954.

Some additional soil applications consisting of urea herbicides mixed with superphosphate were also studied. The results are given in Table 2. Considering the dry weather conditions prevailing after applications were made, fair defoliation occurred. It was late summer before the leaves of the oak plants showed visible symptoms of toxicity from the materials. PDU produced the highest defoliation. Results to date indicate that PDU is more active than the other two chemicals.

As a result of foliage and basal bark treatments, satisfactory kills were obtained with CMU applied at the rate of about 15 pounds per acre in both water and diesel oil. It appears to be equally as effective during the dormant and the growing seasons.

Sprouts. The effect of soil applications of CMU on sprouts is given in Table 3. In general, sprouts were difficult to kill; however, CMU applied in water on the soil produced good defoliation. It appears that even the lowest rate may cause a high degree of kill.

Grasses and Legumes. Native grasses were killed where applications of 7.5 pounds per acre of CMU were made directly on them. However, well-established big and little bluestem, Indiangrass, switchgrass, and sand lovegrass plants have continued to make normal growth and to produce seed following surface soil applications of 15 pounds per acre of the same compound. A number of plantings with Lespedeza sericea, sweet clover, birdsfoot trefoil, and Korean lespedeza have been made on areas where trees have been killed with CMU. All of the legumes germinated, but the seedlings died shortly afterwards with the exception of Lespedeza sericea. This plant is making a fair growth on areas receiving 15 pounds of CMU per acre. The effects that the DCMU and PDU, applied in 1954, will have on grass plants could not be determined due to drought.

Table 2. Effect of Urea Herbicides Mixed with Superphosphate, Applied to the Surface of Soil, on Oak Brush

Herbicide Used	Pounds Per Acre 1/	Percent Defoliation 2/
CMU	7.5	30
"	15.0	50
"	30.0	80
DCMU	7.5	30
"	15.0	70
PDU	7.5	70
"	15.0	80
"	30.0	90

1/ The powder (80 percent active) of each was mixed with 20 percent superphosphate and broadcast on soil at 300 pounds per acre. Application was made February 9, 1954.

2/ Determined from reading made September, 1954.

Table 3. Effect of Soil Applications of CMU on Control of Oak Sprouts Ranging in Size from 3 to 6 Feet, Near Guthrie, Oklahoma

Section No.	Per Acre Application 1/		Percent Defoliation 2/
	Pounds CMU	Gallons Water	
1	23.4	117	90
2	20.3	61	85
3	150.0	-	60
4	76.0	-	50
5	17.3	69	80
6	10.6	64	75

1/ The spray was applied on the surface of the soil with a power sprayer, and the pellets were broadcast by hand. Powder (80 percent active) was used in Sections 1, 2, 5, and 6. Pellets, with respective activities of 10 and 25 percent, were used in Sections 3 and 4. Date of treatment was January 14, 1954.

2/ Determined from readings made September, 1954.

Summary and Conclusion

The 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU) has satisfactorily killed oak and most associated woody species. This chemical was most effective when applied at rates of 1/8 to 1/4 pound (approximately 7.5 to 15 pounds per acre) of 80 percent active powder per gallon of water, with the spray being applied on the surface of the soil around each plant. It appears to be equally effective during both dormant and growing seasons.

The urea herbicides, 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea (DCMU) and 3-(phenyl)-1, 1-dimethylurea (PDU), appear to be equal to CMU in killing woody plants. PDU has been slightly more active than the other two materials.

From the results obtained, it appears that urea herbicides have a good place in the treating of brush and trees infesting fence rows, waterways, areas adjacent to cultiviated fields, and most all rights-of-way.

Since these herbicides are apparently toxic to all plants, precaution will need to be observed in applying them near wanted plants that will be affected. CMU has severely affected trees several feet from the point of application.

These materials have no apparent toxicity to man or livestock.

1/ Agric. Res. Serv., Field Crops Research Branch, USDA, and Oklahoma A. and M. College.

2/ Red Plains Conservation Experiment Station, Guthrie, Okla. Appreciation is expressed to DuPont Co. for the herbicides and to Dr. Vernon J. Fisher, Research Rep. for advice.

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CONTROL OF WEED AND GRASS COMPETITION IN FOREST PLANTATIONS

J. E. Kuntz and A. J. Riker

Forest trees are among our most important natural resources and constitute perhaps the only one that can be replaced. Appreciation of this national asset is evidenced not only by intensified efforts to preserve and to improve existing stands, but also to insure future reserves by large scale reforestation with genetically superior, fast-growing tree varieties. Hence, factors influencing tree development have special interest, especially as their effects are magnified by intensive culture on a "crop basis".

The survival and subsequent growth of young forest plantations are severely limited by weed and especially grass competition. These effects are particularly detrimental during the first year or two. Later the trees shade out most competition. Hardwood trees usually suffer more from early grass and weed competition than do conifers. The repeated failures of hardwood plantings and the inherent tolerance of most conifers to early neglect have favored the use of the latter. Still, conifers respond with increased growth to release from weed competition.

Weed and grass competition should not be confused with that from brush or undesirable overstory. Recent and extensive research already has provided materials, tools, and methods to overcome many of the latter difficulties.

Current studies have demonstrated the value of weed control in fruit culture. Chemical weed control in large forest nurseries has replaced to a large degree costly hand weeding in seedbeds. The elimination of weeds in ornamental nursery stocks holds considerable interest for commercial nurserymen. The numerous examples of selective weed control in crop plants offer considerable encouragement to the forest manager.

In forest plantings, weed control by mechanical means has critical limitations. Scalping, furrowing, or disking provide only temporary relief. They may even aggravate the problem. Some sites are unsuited to the use of mechanized equipment because of physical conditions or ground cover. In such cases, hand planting and spot weed control may be necessary.

Since machine planting accounts for at least one-half of the 25,000,000 or more trees planted annually in Wisconsin, for example, trees could be planted and chemical herbicides applied in one operation. A sprayer could be attached to the planter and the herbicides applied to the freshly exposed soil by directing the spray behind the packer wheels. The trees could be protected by shields if necessary. To be most practical, a single application of suitable herbicides or combinations of herbicide at the time of planting should give satisfactory weed control for at least one season without injury to trees.

The purpose of the present investigation was to determine the response of trees to release from weed competition and the possibilities of selective weed control by means of chemical herbicides. During the last six years, replicated plantings have been made in early May on alkaline muck and silt loam in southern Wisconsin and on Plainfield sand in central Wisconsin. Preliminary experiments had shown that both survival and growth of trees planted in unplowed sod were greatly reduced regardless of subsequent elimination of grass above ground. So, for these studies all areas were plowed and disked just prior to planting. Both dormant cottonwood cuttings and jack and red pine transplants were used. Fast growing poplars proved to be excellent test plants because of their rooting ability, their sensitivity to site conditions, and their marked response to release from weed competition. Herbicides usually were applied as pre-emergence treatments immediately after planting, either to the entire plot or to a limited area around each tree. In initial trials, the trees and exposed tops of the cuttings were protected by inverted paper cones. In later trials, sprays were applied to the ground without protecting the trees. Plots were examined monthly and estimates were made of weed control and tree injury.

Suppression of tree growth by weed competition was demonstrated readily. Site factors such as soil type, soil moisture, water table, and weed species originally present modified results considerably. On good sites with adequate moisture and fertility, many trees survived competition from broadleaved weeds even in untreated check plots although first-season terminal and diameter growth were greatly reduced. On loam or muck, about 30 percent of the poplars survived and grew less than one foot in unweeded plots. On undisturbed sod, however, poplars either died or remained small, spindly and chlorotic. In plowed and weeded plots, they commonly survived almost 100 percent and grew four to seven feet during the first season.

On light sandy soils, even with less grass and weeds present, the effects of competition were more damaging than on heavy soil. In unplowed, unweeded check plots, few poplars lived, and terminal growth of the survivors was less than six inches. Most pines survived, but the majority have remained stunted. On plowed, clean-cultivated plots, survival of poplars varied from 80 to 100 percent and terminal growth was over two feet. On all sites where grass and weeds were reduced to the same degree with chemical herbicides (without visual injury to the trees), tree survival and growth were comparable to those on cultivated plots.

The margin of safety between the concentration of certain herbicides necessary to kill weeds and the concentration which caused injury to trees was much less on sand than on sand topped with a light humus layer or on heavier soils. In plantings where a litter and duff layer already had accumulated, considerably higher concentrations could be applied without injury to trees.

Additional evidence of the moderating effects of organic matter was noted in experiments dealing with firelane maintenance. Repeated rototilling had destroyed most of the organic matter in these firelanes. Pines bordering areas treated with CMU at 20 pounds per acre often were killed or severely injured. Yet, trees in adjacent jack pine - scrub oak stands showed little or no injury following small-area treatments with CMU at 25 pounds per acre. This confirms reports by others.

From many herbicides and combinations of herbicides tested, encouragement for selective weed control in forest plantings has resulted from the use of the following chemicals:

On sand: (a) CMU and related substituted ureas at low rates of 2 lb/A, (b) a combination of 2,4-D at 4 lb/A and C-IPC at 20 lb/A, (c) a combination of CMU at 2 lb/A and C-IPC at 20 lb/A, gave satisfactory first-season control of grass and weeds with no apparent injury to the trees. Terminal and diameter growth were comparable to those attained on cultivated plots. June applications of

Dalapon (a, a-dichloropropionic acid) at 10 and 20 lb/A killed all grass foliage without injury to trees, but in some cases, permitted sparse regrowth by late fall.

On loam: somewhat higher concentrations were used safely. A combination of 2, 4-D at 4 lb/A and TCA at 10 lb/A also gave satisfactory weed control with little injury to poplars.

On muck: (a) CMU and related substituted ureas at 4 lb/A, (b) a combination of CMU at 4 lb/A with C-IPC at 20 lb/A, (c) endothal at 20 lb/A, and (d) TCA at 10 lb/A all controlled most grass and weeds with no injury to poplars. TCA at 10 lb/A caused a slight burning of pine needles. June applications of Dalapon at 10 and 20 lb/A eliminated all grass but again permitted a dense growth of broadleaved weeds. A subsequent application of 2, 4-D on selected plots eliminated most of these weeds.

In other studies involving weed control in 1-, 2-, and 3-year-old poplars, it was found that older trees tolerate concentrations of herbicides which frequently injured newly planted trees. Undoubtedly, root distribution accounted for a part of this difference. In 3-year-old poplar plantings, CMU at 8 lb/A and a mixture of CMU at 2 and 4 lb/A with C-IPC at 20 lb/A gave excellent weed control with no injury to trees. Dalapon at 20 and 40 lb/A killed grass foliage with no injury to trees including 6-year-old pines. Weed populations often changed markedly following chemical treatment. Broadleaved weeds invaded areas from which grass had been eliminated and occasionally the opposite happened.

Since both materials and methods continue to improve, and since conditions vary from place to place, no recommendations are made. However, the response of trees to release from weed competition and the encouraging results of selected herbicides have demonstrated that selective weed control in forest plantations is possible. Knowing the site conditions with which we are working, we are using herbicides to establish test plantings of fast-growing, hybrid poplars.

1/ Dept. of Plant Pathology, Univ. of Wisconsin, Madison, Wisc., in cooperation with the Wisconsin Conservation Department and the Nekoosa-Edwards Paper Company.

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CHEMICAL WEED CONTROL IN SHELTERBELTS

E. K. Ferrell 1/

Introduction

Control of weed and grass competition is essential to successful establishment of tree shelterbelts in the Northern Great Plains. While removal of competing vegetation between the tree rows can readily be accomplished with tillage equipment, removal of such vegetation in the tree rows is a difficult problem. It was the purpose of this study: to find a herbicide that would effectively destroy competing vegetation in shelterbelt tree rows without damaging the trees; to determine the effect of chemical weeding on survival and growth of shelterbelt trees and shrubs; to determine the optimum date for application of the herbicides tested.

Materials and Methods

The experimental work was carried out in two one-year old shelterbelts during the spring and summer of 1953. One of these plantings was located in Brookings County, South Dakota, hereafter referred to as Shelterbelt Number One. The second planting was located in Lake County, South Dakota, hereafter referred to as Shelterbelt Number Two.

Eight species, five treatments and nine different dates of application were included in the experiments. Species tested and rate of application of herbicides are as follows:

Species:
Honeysuckle (Lonicera tatarica)
Nanking cherry (Prunus tomentosa)
Green ash (Fraxinus pennsylvanica lanceolata)
Hackberry (Celtis occidentalis)
American elm (Ulmus americana)
Harbin pear (Pyrus ussuriensis)
Siberian elm (Ulmus pumila)
Redcedar (Juniperus virginiana)

Table 1. Rate of Application of Herbicides

Treatment	Rate of Application (per acre)
DNBP	1 1/8 lb (1)
Stoddard Solvent	50 gal.
Ammate	352 lb (2)
CMU	20 lb (3)
SES	2 1/4 lb (4)

(1) Phenol equivalent (Mixed with 16 gals. diesel oil and 144 gals. water)
(2) Active ingredient (0.8 lb/gal of water)
(3) Active ingredient (Applied in 435 gals. of water)
(4) Active ingredient (Applied in 40 gals. of water)

Using a five gallon hand pressure knapsack sprayer, each herbicide was applied to plots in both shelterbelts, care being taken to avoid spraying the tree foliage.

The plots were one foot wide and 18 feet long in five tree rows in each shelterbelt. In Shelterbelt Number One each herbicide was applied to 30 plots, half of these being treated on one date and half on a later date. In Shelterbelt Number Two each herbicide was applied to 15 plots and each treatment was made on a different date. In both shelterbelts the experimental design was a rendomized block with three replications.

The number of broad-leaved and grassy weeds was counted in square foot samples selected at random in each test plot. These counts were compared with untreated check plots to determine which herbicide was most effective. Heights and diameters of trees and shrubs in the test plots were secured at the beginning and end of the growing season and compared to determine whether the herbicides under test exerted any effect on growth. Survival counts were also made at the beginning and end of the growing season to determine what effect chemical treatment had on survival. Soil moisture determinations were made in the fall to compare the effects of treatment with CMU, clean cultivation and no treatment on soil moisture content.

Effect on Weed Growth

Grassy weeds in both shelterbelts consisted almost entirely of green foxtail (Setaria viridis) and wild barley (Hordeum jubatum). Broad-leaved weeds were mainly

prostrate pigweed (Amaranthus blitoides), rough pigweed (Amaranthus retroflexus), and lambsquarters (Chenopodium album).

The average number of weeds per square foot in Shelterbelt Number One is given for each treatment and date of treatment in Table 2.

Table 2. Average number of weeds per square foot after treatment with five herbicides applied on two dates--Shelterbelt Number One.

Treatment	Date Applied	Average number of weeds per square foot (1) July 4, 1953	Compared with untreated
Untreated	---	80.1	--
DNBP	6/10/53	24.0	-56.1**
DNBP	6/20/53	65.3	-14.8
Stoddard Solvent	6/10/53	31.5	-48.6**
Stoddard Solvent	6/20/53	74.0	- 6.1
Ammate	6/10/53	27.9	-52.2**
Ammate	6/20/53	30.0	-50.1**
CMU	6/10/53	3.5	-76.6**
CMU	6/20/53	1.5	-78.6**
SES	5/5/53	48.3	-31.8**
SES	5/14/53	37.6	-42.5**

** Significant at 1@ level
(1) Level required for significance at .05=20.2 weeds; at .01= 28.5 weeds.

Statistically significant differences existed between dates of treatment for both DNBP and Stoddard Solvent while no significant differences existed between dates for Ammate, CMU or SES. More efficient weed control obtained with the earlier applications of DNBP and Stoddard Solvent as contrasted with the later applications of these two herbicides is probably due to the fact that grassy weed growth averaged six inches in height at the time of June 10 application and 10 inches in height on June 20. Broad-leaved weeds averaged two inches in height on June 10 and four inches on June 20. Taller weed growth on the later date made it difficult to wet the plants thoroughly with the spray. Weather conditions might also have had some influence. Temperature at time of application on June 10 was 75° F., with a slight breeze blowing. On June 20 the temperature was 67° F. at the time of application and a strong wind caused considerable spray drift.

Table 3. Average number of weeds per square foot after treatment with five herbicides applied on five dates--Shelterbelt Number Two.

Treatment	Date Applied	Average number of weeds per square foot (1) June 27, 1953	Compared with untreated
Untreated	---	81.0	---
DNBP	6/18/53	70.1	-10.9*
Stoddard Solvent	6/3/53	54.6	-26.4**
Ammate	6/12/53	6.9	-74.1**
CMU	5/19/53	3.1	-77.9**
SES	5/7/53	41.6	-39.4**

** Significant at 1% level
* Significant at 5% level
(1) Level required for significance at .05=9.5 weeds; at .01=13.9 weeds

As indicated in Table 3, DNBP was the least effective herbicide in Shelterbelt Number Two. At the time of application of this chemical, grassy weeds averaged 12 inches in height. As a result, most of the spray contacted only the upper parts of the plants. Broad-leaved weeds, while slightly shorter in average height than the grassy weeds, contained some individuals in the population up to 24 inches high. These large specimens tended to shield the understory of grassy weeds from the spray. The advanced state of weed growth when DNBP was applied undoubtedly accounts for the unsatisfactory results obtained with this herbicide. This corresponds with results obtained in Shelterbelt Number One, where the later application of DNBP was much less satisfactory than the earlier application.

Effect on Tree Growth

Table 4. Average height growth of Eastern redcedar after treatment with five herbicides. Shelterbelt Number One.

Treatment	Average height growth (inches)	Average height growth compared with untreated (inches) (1)
Untreated	5.6	---
DNBP	5.9	+0.3
Stoddard Solvent	6.3	+0.7
Ammate	4.7	-0.9
CMU	10.0	+4.4**
SES	6.2	+0.6

** Significant at 1% level
(1) Level required for significance at .05=2.8 inches; at .01=4.0 inches

As indicated in Table 4, a highly significant difference in height growth was obtained for Eastern redcedar treated with CMU. F-tests were applied to all other species in the experiment, but failed to show any significant differences in height growth. With the exception of CMU, none of the herbicides tested exerted a significantly beneficial or harmful effect on height growth of any of the species included in the experiment. Since Eastern redcedar is a slow growing tree it is quickly overtopped by competing vegetation. Excellent weed control obtained with CMU apparently benefitted the slow growing redcedar to a much greater extent than the faster growing hardwoods. No significant difference in diameter growth was obtained for any of the species tested.

Effect on Soil Moisture

Table 5. Soil moisture percentages for chemical treatment, clean cultivation and no treatment at six-inch, 12-inch and 24-inch depths. Shelterbelt Number One.

Treatment	Depth-Inches	Percent Moisture
Check	6	10.71
Check	12	10.06
Check	24	9.28
CMU	6	18.84
CMU	12	19.74
CMU	24	17.79
Clean cultivation	6	16.34
Clean cultivation	12	18.37
Clean cultivation	24	17.64

The data in Table 5 clearly indicate the depleting effect of weed growth on soil moisture and also indicate that effective chemical weeding conserved soil moisture slightly better than clean cultivation.

Summary and Conclusions

CMU was the most effective weed killer of the five herbicides tested. CMU gave excellent control of both broad-leaved and grassy weeds regardless of date applied. Date of application is important when using DNBP and Stoddard Solvent. The earlier applications of these two herbicides gave far better results than did the later applications.

CMU was the only herbicide tested that exerted a significantly beneficial effect on height growth and this was evident only in the case of redcedar. None of the other herbicides exerted a beneficial or harmful effect on height growth of any of the species tested. None of the herbicides tested exerted a significantly beneficial or harmful effect on survival. Followup inspections made during the 1954 growing season failed to reveal any tree losses in the treated plots.

Plots treated with CMU remained practically weed free throughout the 1953 and 1954 growing seasons.

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2,4-D OR MCP FOR WEED CONTROL IN FLAX, OATS, AND LEGUMES 1/

R. S. Dunham 2/

MCP is more expensive than 2,4-D. How then can a preference for MCP over 2,4-D be justified? The answer is found in the greater tolerance of some crops to this herbicide. When either MCP or 2,4-D is used on a weed-free crop, almost inevitably the yield is reduced in proportion to the amount applied. When the herbicide is used successfully on a weedy crop, the injury is less from the chemical than it would have been from the weeds. The data in Table 1 illustrate this fact. Thus 3, 4, and 8 oz. of 2,4-D reduced the yield of weed-free flax 1.4, 2 and 6 bushels respectively. In flax infested with wild mustard, however, the use of 3 oz. increased the yield over the untreated check.

Flax is one of the crops for which MCP is recommended. In Table 1, data from Minnesota trials show that 4 oz. of 2,4-D reduced the yield of weed-free flax 2 bu. but 4 oz. of MCP only 0.1 bu. In the weedy flax, 4 oz. reduced the yield 1.1 bu. but 4 oz. of MCP resulted in 1.5 bu. increase and even 6 oz. showed a slight increase. The table also shows that both herbicides were effective on mustard.

Table 1. Yields of Weed-Free and Weedy Flax Sprayed With 2,4-D and MCP Amines and Stands of Mustard Remaining.

Treatment oz. per acre		Yield in bu./A Weed-free	Yield in bu./A Weedy	Wild mustard No. plants/plot
2,4-D	0	16.0	12.8	98
	2	16.2	13.7	3
	3	14.6	13.3	1
	4	14.0	11.7	1
	8	10.0	10.0	0
MCP	0	15.6	12.1	91
	4	15.5	13.6	0
	6	14.4	12.5	0
	8	12.4	10.4	0

In Minnesota, 23 comparisons of 2,4-D and MCP on weed-free flax have been made over a three-year period. Four ounces of the amine salt of each herbicide per acre were sprayed on a total of 10 varieties. As an average of all trials, treated flax yielded 90 per cent of the untreated check when sprayed with 2,4-D and 97 per cent of the check when MCP was used. Similar results have been obtained by a number of other investigators.

Varieties of flax differ widely in their reaction to 2,4-D. A tolerant variety has been uninjured from an application of four times the amount of 2,4-D that reduced the yield of a susceptible variety. Variety response to MCP at recommended rates or slightly above is not nearly so distinct. In the flax nursery at University Farm, St. Paul, 23 varieties or new strains of flax were sprayed with 5 oz. of MCP this year. As an average of all varieties the date of bloom was delayed two days and the date of ripening one day. The yield was reduced 2.6 bushels. This was weed-free flax and sprayed with one ounce over the recommended amount. A statistical analysis of the data showed no significant difference among the varieties in response to spraying.

For flax MCP is safer when varieties susceptible to 2,4-D are grown, it is safer under unfavorable weather conditions which pre-dispose flax to spray injury, and it is safer to use on clean portions of a field where spotted weed infestations exist.

Oats, like flax, is more tolerant of MCP than 2,4-D. This is especially true of some varieties, as indicated in Table 2. Where there is a need to grow an early variety that is subject to injury from 2,4-D, the additional cost of MCP may be justified. In Table 3 barley varieties show a similar greater tolerance of MCP than 2,4-D. The rate of 12 oz. per acre is more than is recommend and injury from both MCP and 2,4-D is greater than would be expected from the common 8 oz. rate. Using the higher rate, however, makes differences more apparent and can be justified for experimental work. Where farmers have experienced injury to barley from recommended rates of 2,4-D, a trial of MCP is suggested.

Table 2. Response of Weed-Free Oat Varieties to 12 oz. of 2,4-D or MCP (Yields in Per Cent of Check)

Varieties	2,4-D	MCP
Bonda	93	95
Mindo	67	86
Clinton	77	87
Andrew	81	98
Ajax	94	107
Shelby	90	91

Table 3. Response of Weed-Free Barley Varieties to 12 oz. of 2,4-D and MCP (Yields in Per Cent of Check)

Varieties	2,4-D	MCP
Barbless	90.0	98.0
Mars	94.7	102.6
Kindred	82.5	90.8
Montcalm	78.4	82.3
Moore	109.0	105.6
Plains	70.8	94.1
Vantage	76.5	65.9

The response of legumes to 2,4-D or MCP is difficult to summarize. Greater tolerance of MCP has been reported by some investigators and greater tolerance of 2,4-D by the same legume has been reported by others. In Minnesota, no consistent difference has shown up when the legumes have been used for forage purposes and when recommended amounts of the herbicide have been applied. MCP has been recommended when the legume is sown with flax because of the greater tolerance of the companion crop for this herbicide.

However, legumes grown for seed production in the northern part of the state have shown some differences in one year of trial. Yields of red clover seed were greatly reduced by applications of 4 ounces of 2,4-D or MCP made when the regrowth of the clover after clipping was 5-6 inches tall. Yields on the MCP treated plots were approximately three times those on the 2,4-D treated plots. The check averaged about twice the yield of the MCP treated plots. The bloom of alfalfa was more seriously reduced by 2,4-D than MCP. But alsike clover showed a greater recovery at harvest on the 2,4-D treated plots than the MCP plots.

Since the primary function of an herbicide is to kill weeds, it is important to know whether they show a greater or less tolerance of MCP. Work by Coupland of Saskatchewan, Schmidt of Germany (1), and Dunham & Robinson has furnished the information in Table 4. Those species above the underlining have shown definite differences; the response of those below the line has not been so distinct.

Table 4. Weeds That Are Controlled More Easily by MCP Than 2,4-D or Vice Versa

MCP	2,4-D
Hemp nettle	Russian thistle
Horse tail	False flax
Buttercup	Wild buckwheat
Tartary buckwheat	Velvet weed
Corn spurry	Jimson weed
Corn cockle	Smartweed
Per. peppergrass	Redroot pigweed
	Ball mustard
	Tansy mustard=
	Wild hemp

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1/ Paper No. 3285 of the Scientific Journal Series, Univ. of Minnesota, St. Paul, Minnesota

2/ University of Minnesota, St. Paul, Minnesota

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PERENNIAL WEED CONTROL

Lyle A. Derscheid 1/

It is important to control perennial weeds because most species have the capability of seriously reducing crop yields. Field bindweed, for example, reduces the yields of small grain by 1/3 to 1/2 even in a good small grain year. The average yield of 12 oat fields was decreased from 44.6 to 30 bushels per acre in South Dakota, while the average yield of 8 wheat fields was reduced from 21.7 to 12.6 bushels per acre. In Kansas this weed caused the yield of barley to be decreased from 21.5 to 7.5 bushels per acre and reduced the yield of sorghum from 3.92 to 2.06 tons per acre. Likewise, a heavy infestation of perennial sow thistle lowered oat yields from 54.3 to 17 bushels per acre in South Dakota.

Our most troublesome perennial weeds spread rapidly once they become established. Seeds scattered by one method or another start new infestations and they help to spread the infestation, but many weeds can spread very rapidly from underground parts (roots, rhizomes etc.). A single bindweed seedling, for example, is capable of spreading over an area 10 feet in diameter in three months or 17 feet in three growing seasons. As it spreads laterally it also goes deeper into the soil. Many roots extend, down to a depth of 15 to 20 feet. Likewise, one hoary cress seedling can spread over an area 6 feet in diameter in one season or 11 feet in two seasons. Many of our other most troublesome weeds spread in a similar manner.

Since these weeds are capable of spreading so fast, it is most practical to kill out new infestations before they have a chance to spread. It costs less than one dollar to eliminate a square-rod patch, but may cost hundreds of dollars to eliminate the weeds if allowed to spread over an entire field.

When we try to control perennial weeds, we try to starve them by depleting the food reserves in the roots. These food reserves are commonly called root reserves. We use cultivation, competitive crops and even chemicals in an attempt to starve perennial weeds. We can do a better job of starving these weeds if we understand how the plant makes and stores its food.

Plants take carbon dioxide out of the air and water from the soil. With the aid of sunlight they manufacture sugar in the leaves. If more sugar is produced than is needed for the growth of the plant, the excess moves to the roots and is stored in the form of starch. Plants also take nitrogen, phosphorus and other nutrients from the soil (some plants take nitrogen out of the air). The elements are combined with the sugars to form protein and other plant foods. Any of these foods not needed for growth are also stored in the roots as root reserves.

We can starve the weeds if we slow down the manufacturing of sugar in the leaves or if we can decrease the uptake of water, nitrogen, phosphorus and other nutrients to

the point that less food is produced than is needed for growth. Some competitive crops shade the leaves and reduce the amount of sugar that is produced; others compete with the weeds for nutrients from the soil. The best competitive plants do both -- shade the leaves and compete for nutrients.

We can also starve the weeds if we cause them to use up their root reserves. Intensive cultivation and some chemicals will cause plants to do this. Cultivation is used to cut the roots four inches below the soil surface. It takes about six days for shoots from bindweed roots, and a similar amount of time for several other species, to grow back to the soil surface. Root reserves are used for this growth and in bindweed they are used for about eight days afterwards, until there are enough leaves to produce plant food faster than it is used. It actually takes twice as much root reserve to produce top growth of bindweed for eight days as it does to produce the subsurface growth for six days. Consequently, root reserves of bindweed are depleted faster if the tops are allowed to grow for eight days before they are cut off than they would be if cultivated as soon as top growth appeared. This is why most people recommend that cultivation be done every two weeks. Sodium chlorate, 2, 4-D and several relatives of 2, 4-D reduce the root reserves of perennial plants. Chlorate enters through the roots, while 2, 4-D goes in through the leaves and is translocated to the roots, but both cause the plant to use up much of its root reserves.

Many of our commonly grown crops can be used with cultivation and 2, 4-D to eliminate perennial weeds. Such crops as winter rye, winter wheat, perennial grasses, close-drilled forage sorghum or sudan grass shade the weeds and reduce the amount of sugar produced in the leaves; they also compete for soil nutrients in the upper layer of soil-- some compete more than others. Alfalfa and other deep rooted crops shade the weeds and compete for soil nutrients all the way down to a depth of 15 or 20 feet. The cultivation helps reduce the root reserves.

Alfalfa alone or a mixture of alfalfa and an adapted perennial grass are excellent competitive crops and can be used to control field bindweed, leafy spurge, Russian knapweed, thistles and others. The weeds should be cultivated for one summer. If there is sufficient moisture about August 15, the crop can be seeded in South Dakota. Otherwise, the cultivation can be continued until fall and the crop seeded the next spring. Fall seedings should be sown with a light rate of a companion crop, such as oats, to reduce erosion over winter. These crops can be cut for hay and will eliminate 99% of thistles in 3 years or a similar number of bindweed in 4 or 5 years. The grasses can be used alone in a similar manner, but should be sprayed once or twice a year with 2, 4-D.

Rye or winter wheat when used with intensive cultivation will eliminate field bindweed, leafy spurge, Canada thistle, perennial sow thistle, Russian knapweed or hoary cress. The land should be intensively cultivated from spring until the crop is seeded. After the crop is harvested, the field should be cultivated until the crop is seeded again. Several years are generally required to give complete elimination. Barley and oats used in a similar manner have been effective for eliminating bindweed and thistles, but spring seeded crops are less effective on leafy spurge and other early emerging species.

Forage sorghum, sudan grass and soybeans, when used in conjunction with intensive cultivation are effective for the control of field bindweed, Canada thistle or perennial sow thistle. Sudan grass is effective on leafy spurge, while buckwheat, where adapted, is helpful in controlling spurge and quackgrass. The land should be cultivated until about July 1 in this area. If sufficient moisture is available the crop adapted to the area and the weed to be controlled should be seeded at a heavy rate with a grain drill. The crop, except buckwheat, should be harvested for forage. The land is then cultivated until freezeup. If there is not sufficient moisture in June to warrant seeding the crop, intensive cultivation can be continued all season.

Late fall plowing is an effective method of reducing the stands of bindweed, thistles, and quackgrass. Deep plowing just before freezeup has completely eliminated thistles in some cases. Shallow plowing in November exposes rhizomes of quackgrass to freezing reducing the stand and retarding spring growth.

So far we have considered cultural practices, primarily, but chemicals can be used to supplement these practices. Sodium chlorate, borax compounds, borate-chlorate mixtures, amate, CMU, relatives of CMU, and borate-2, 4-D mixtures can be used without cultural practices to eliminate small patches. However, they cost too much to be used on large infestations. 2, 4-D, MCP and 2, 4, 5-T, can be used in conjunction with cultural methods to eliminate large infestations of broad-leaved perennial weeds quicker, while TCA, MH, and Dalapon can be used in a similar manner on grassy perennials. Other chemicals will come along which will fit into the picture.

2, 4-D can be used on a large number of weeds and should be used whenever possible. The amount and formulation used will depend on the weed and the results expected. Generally speaking, 1/2 to 1 pound of 2, 4-D acid per acre will need to be used. The lighter rate will prevent seeding of most species and will knock them down so that they do not interfere with harvesting. However, this amount probably will not reduce the stand materially. A rate of 3/4 to 1 pound per acre will often help reduce the stand. These higher rates may injure crops so we have two choices: (1) risk injuring the crop and get a good weed control, or (2) get poor weed control with less risk of injuring the crop. The advantage gained in weed control will, in the long run, usually offset the damage to the crop.

Another method of using 2, 4-D is being investigated in this area. Work done in Nebraska and a limited amount of work in South Dakota indicate that late fall applications of 10 pounds per acre of 2, 4-D will eliminate hoary cress or 25-40 pounds will kill leafy spurge, Russian knapweed or tan weed. The amines have been more satisfactory than the ester forms. These treatments appear promising on thistles but to date have not been satisfactory on field bindweed.

2. 4-D is the best chemical for use on most of our broad-leaved perennial weeds, however, MCP is sometimes better on Canada thistle and 2, 4, 5-T is more effective on horse nettle and some woody plants. TCA, MH and Dalapon are effective for controlling quackgrass and other grassy perennials.

TCA should be applied to freshly plowed sod in the fall or early spring. There is some residual effect from the chemical but oats, corn or flax can usually be seeded the spring after fall applications are made. MH should be applied when the quackgrass is four to eight inches tall. Three to six days later the area should be plowed and seeded to small grain or corn. The crops appear to improve the effectiveness of the chemical. Dalapon can be used in much the same way as MH.

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WILD OAT CONTROL

H. E. Wood 1/

Two years ago when addressing the North Central Weed Control Conference on the "Occurrence of Wild Oats", the writer stated:

> "The Wild Oat, (Avena fatua L.) is one of the most widespread and troublesome of the numerous species of established noxious weeds. This applies to almost the entire cultivated portion of the Northern Plains of the Great Plains Region of North America."

A survey revealed that the area of wild oat infestation included the northern half of South Dakota, the north-west corner of Minnesota, most of North Dakota and Montana; likewise the greater portion of the Prairie Provinces, Manitoba, Saskatchewan and Alberta. Of 106 million acres under crop, 61 million acres were wild oat infested, 29 million acres seriously.

A year ago an appraisal of the loss caused by weeds throughout the three Prairie Provinces of Canada was made based on 1953 yields and prices. It was conservatively estimated that weeds were responsible that year for a toll of $255 million, an average of $1,028 per farm. On the basis that wild oats account for as great if not greater toll than all other weed species, one might assume that on the average Prairie farm wild oats are responsible for a loss of at least $500 annually.

The general attitude of farmers toward weed control, particularly wild oats, was indicated through a questionnaire returned to the writer by those in charge of weed control, in Western Canada and the North-Central States in which this weed is a problem. While over the last two years little or no headway has been made in control, there does appear to be a changing attitude on the part of farmers toward controlling this menace. Generally, there is both a growing concern and definite indications of a determination to master the problem, which is a most hopeful and encouraging sign.

The serious problem wild oat control presents hinges around seed dormancy, and the lengthy but variable after-ripening period necessary before germination commences and is completed. Second only to this is the type of farming practiced over practically the entire wild oat infested area -- extensive small grain growing, with a minimum of inter-tilled and/or hay crops. Ponder these two points and you come face to face with the tremendously difficult problem presented in wild oat control.

As one moves north of the International Boundary, by far the most common method of control is that of delayed seeding. After one or two growths of wild oats are killed by tillage, oats, barley or flax is planted. When carried on over a sufficient number of years this practice undoubtedly is an effective means of ridding land of wild oats. However, delayed seeding has very serious practical drawbacks, in some years.

The objections to delayed seeding may be briefly stated as follows. It is not every spring that an early and satisfactory germination of wild oats can be obtained; in which case planting is unduly delayed. Under such conditions returns oftentimes are disappointing. Even when a heavy growth of wild oats is destroyed fairly early in the season the returns from the substitute crop may fall considerably below that of wheat, had it been planted under normal conditions.

The value of fertilizer, whether the crop is early seeded or delayed, is gaining recognition. Its use boosts early crop growth, thereby giving added competition to wild oats through more vigorous growth.

Only the occasional farmer uses post-seeding tillage as a means of wild oat control. Where favorable soil conditions permit this, and providing tillage is carried out within 5 or 6 days of planting -- or before the new shoot on the seed is more than 3/4 inch in length -- it is surprising how well this method works. While the rod or cable-weeder is preferred, any implement that will operate above the seed can be used. Cultivation is best cross-wise of planting and carried out when the weather is dry and sunny.

Competitive crops should not be overlooked. An early variety of barley heavily seeded and properly fertilized, offers very considerable competition. Quick growing crops, such as buckwheat and millet, are highly competitive. In areas where fall rye or other fall-planted crops can be used, and especially in the more northern districts where delayed seeding is not feasible, this type of crop will be found to compete aggressively with wild oats.

Row crops, where they can be used, will be found helpful. A recent interesting move on the part of a number of Manitoba farmers is that of growing grain in 20 inch rather than 6 inch rows, thereby permitting early seeding and working out much of the wild oats by two or three cultivations between rows.

Too little attention has been given to sacrificing a wild oat polluted crop when control measures have failed, by either mowing, plowing or cultivating out the crop. In the majority of cases portions only, rather than the entire field, need be sacrificed. When this practice is followed operations should commence quite early, thereby preventing viable wild oat seeds forming.

Greater use of grasses and legumes cannot be overemphasized in any weed control program. To overcome the few remaining viable wild oat seeds from re-infesting the soil, two alternatives may be followed. Break early to permit fallowing for the balance of the season, or break later with the object of summerfallowing the following season.

For wild oat control, summerfallowing has proven unsatisfactory and disappointing. Probably more attention should be given to ways and means of inducing wild oats to germinate in the fallow year. This might include: the same fall-spring tillage as used where delayed seeding is followed; by packing to conserve moisture and keep down soil temperatures; and avoidance of too frequent cul-

tivation, which brings to the surface and after-ripens additional wild oats, in which case delayed seeding the following spring would be essential. Consideration might be given to the use of herbicides, especially for certain perennial weeds, thereby reducing the amount of tillage, while encouraging wild oat growth. Where one is certain he has failed to destroy the major portion of wild oats in the fallow year it is better to delay seeding, rather than have an early planted but wild oat polluted crop.

1/ Manitoba Dept of Agriculture, Winnipeg, Manitoba

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CHEMICAL CONTROL OF WILD OATS

E. A. Helgeson 1/

Our discovery in 1950 that TCA would control pigeon grass in sugar beets stimulated the search for a selective chemical for wild oats control in a growing crop. It was soon shown that TCA was not suitable since amounts required for control of this pest were above the tolerance of any crop feasible for the Northern Great Plains. As a result of extensive field studies every year since 1951 it has been shown that Endothal could be used as a post-emergence spray to control wild oats in sugar beets. While this chemical gives fair to good control at around 6 lbs per acre it also reduces beet yields around 1 1/2 tons per acre. A search for other crops tolerant of this chemical have been promising but not as yet entirely successful.

For some time we have been studying the possibility of spraying wild oat seeds on the ground and then plowing or disking them under to be killed by the chemical when they sprout or to be killed by rots stimulated by chemicals so applied. Our first attempts along this line were with Endothal applied to oats in flats in the greenhouse. After treatment seeds were allowed to remain for varying periods of time on the surface before covering with soil. At rates of 6 to 8 lbs. per acre excellent control was obtained regardless of the time period elapsed before covering.

Several years ago Nelson in Colorado showed that IPC and CIPC would control wild oats in sugar beets at 6 lbs. per acre when disked into the soil just before planting of beets. We tried this in the spring of 1953 using IPC, CIPC, Endothal, TCA and CMU. At 4 lbs. for CMU and 8 to 12 lbs. for the other chemicals good wild oats control was obtained. Sugar beets tolerate IPC, Endothal and TCA; flax TCA only; corn none of the chemicals used; soybeans IPC only; and sunflower IPC and CIPC. CMU killed all these crops. The principal drawback to these spring treatments is that stirring the soil tends to dry the surface so that the germination of shallow seeded crops is poor.

To overcome the objectional drying of soil from spring pre-planting treatments we along with workers in Canada and Minnesota have more recently tried fall spraying. It was thought that by disking herbicides into the soil late in the fall they might remain in the soil during the winter and be at hand in early spring to kill germinating seeds. Low winter temperatures would curtail microbial action and if a chemical such as IPC could be used this would decompose in time to allow spring planting of a crop. With this in mind we applied IPC at 8, 12, and 18 lbs. actual material per acre and TCA at the same rate based on the acid equivalent, to field plots naturally infested with wild oats. We also applied some mixtures of the two such as 6 lbs. and 9 lbs. per acre. Chemicals were all applied on October 17, 1953 and the field was then double disked to a depth of about 4 or 5 inches. Sugar beets were planted in the spring after the soil had been properly fitted. Counts on wild oat plants and sugar beet plants made later after plants had emerged showed that both IPC and TCA even at rates as low as 8 lbs. per acre gave excellent control of the wild oat. The IPC chemical seemed to have little effect on beet seedling emergence but the TCA showed a little reduction in beet stands. No further effect appeared on beets later in the season.

The most recent grass killer Dalapon shows great promise for wild oat eradication in sugar beets but this chemical seems to be too toxic for the other crops tested to date. Dalapon has a stimulating effect on the oat causing the production of large numbers of malformed tillers, as many as 19 being counted 6 weeks after the spray was applied. The resulting plant looks more like a cactus than a wild oat plant. Dalapon does the same thing to pigeon grass too. Rates as low as 4 lbs. per acre gave excellent wild oat control when applied post-emergence at the early and fully tillered stage, and fair control when applied at the seedling stage. Where plants are not entirely killed they are so badly injured that seed production is largely stopped.

Another approach to the chemical control problem is in the use of the hormone chemical called Maleic hydrazide. This chemical has been used to stop plant growth such as grass along highways or lawns to reduce the number of mowings required. It seems to have an action which prevents plant cells from dividing so growth stops and in some cases where cells do divide they are abnormal. When sprayed on wild oats in the boot stage the embryos are prevented from developing and seeds formed will not germinate or grow. Mr. Knowles in Canada discovered this several years ago and he found that he could spray wild oats in flax, using as little as 1 lb. of maleic hydrazide per acre and prevent seed development of the oat without hurting the flax. He did the same thing with barley.

The past year several of us in the N. C. W. C. C. have tried this but as yet we don't know what our results are. The main trouble is we don't know how to tell whether wild oats that won't germinate are dead or merely dormant. We are working on methods to tell us whether these seeds are still alive or dead but as yet we can't tell for sure. After all it won't matter much, for if we can put these seeds to sleep and keep them that way they will eventually die.

This then is a summary of our chemical work so far. We have some promising results and it seems certain that with all the new chemicals industry is giving us we will finally find one which will kill the wild oats and one which will be selective enough to use in a crop.

1/ North Dakota Agricultural Experiment Station, Fargo, North Dakota

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EFFECT OF MUSTARD IN WHEAT AND FLAX

L. H. Shebeski 1/

Wild mustard has been, and is, very prevalent on the Red River soils of Manitoba. Because of its susceptibility to 2, 4-D and MCP it should be only a matter of time before wild mustard is eliminated from polluted farms. However, many farmers question the need for spraying when mustard infestation is light. Some farmers doubt that sprayed fields yield more grain than unsprayed fields.

In 1952 and 1953 experiments were conducted by Olson and Burrows to determine (a) how many mustard plants per square yard may be tolerated before yields of wheat and flax will be reduced, and (b) does spraying prevent the loss of yield?

In 1952, Dakota flax (seeded at 45 lbs per acre) and Lee wheat (seeded at 2 bu. per acre) were grown alone and in association with 10, 25, 50, 100, 200 and 400 mustard plants per square yard. In 1953 the mustard population levels were changed to 5, 10, 25, 50 and 100 for Redwood flax and to 50, 100, 200, and 400 for Lee wheat. The mustard populations were obtained by sowing predetermined quantities of seed and then thinning to the desired stand at emergence.

In 1952 and 1953 flax and wheat plots were divided into 2, 4-D treated and untreated halves. In both years and in both crops the chemical applied was 2, 4-D butyl ester. Flax was sprayed with 4 oz. acid equivalent per acre at the 2-3 inch stage of growth in 1952 and with 3 oz. per acre at the 1-2 inch stage in 1953. Wheat was sprayed with 6 oz. per acre at the 5-leaf stage in 1952 and with 4 oz. at the early 4-leaf stage in 1953. Mustard control was excellent in both crops in both years.

With flax as few as 10 mustard plants per square yard greatly reduced yields, but by spraying, yields were reasonably well maintained. A few of the yield results are presented in Table I.

Table I. Flax yields - Bu. per acre

	Mustard plants per square yard	Treated	Untreated
1952	0	19.3	22.0
	10	17.7	8.1
	25	17.1	6.2
	100	15.3	3.6
1953	0	11.3	13.8
	10	8.8	6.4
	25	13.8	3.9
	100	13.0	1.1

Obviously it pays to spray flax even with light infestations of mustard. The early spraying in 1953 gave no yield reductions when compared with the unsprayed weed free check. In the untreated plots yields were reduced because of a reduction in basal branching and therefore a reduction of the number of seed bolls per plant.

In wheat, at least 50 mustard plants per square yard were required before significant yield reductions were observed. Some of the results are presented in Table II.

Table II. Wheat yields - Bu. per acre

	Mustard plants per square yard	Treated	Untreated
1952	0	40.7	36.5
	25	37.1	37.0
	50	35.3	32.2
	100	28.7	29.2
1953	0	22.5	22.9
	50	22.6	18.4
	100	23.2	15.7
	200	22.4	13.4

Spraying for control of mustard did not maintain wheat yields in 1952 even though the mustard was destroyed. Apparently the reduction in wheat yields was caused before the mustard was destroyed. Wheat was only in the 5-leaf stage at the time of spraying.

An experiment was conducted in 1954 to determine when in the growth of mustard and wheat does the competition become effective in reducing yields.

Wheat free of mustard and also with concentrations of 100 and 200 mustard plants per square yard was treated with 4 oz. of 2, 4-D butyl ester at 19, 29 and 35 days after the emergence of wheat. At 19 days after emergence, wheat was in the 4-leaf stage; at 29 days after emergence it was in the 6-leaf stage; and 35 days after emergence it was in the shot-blade. At the last date of treatment, mustard was in bloom.

The yields of wheat obtained at harvest are presented in Table III.

Table III. Wheat Yields - bu. per acre

Time of Treatment	Mustard plants per sq. yard	Wheat yield
None	0	42.0
	100	18.4
	200	16.0
19 days	0	45.8
	100	47.1
	200	40.0
29 days	0	48.9
	100	39.1
	200	40.5
35 days	0	44.3
	100	18.8
	200	15.4

In addition to obtaining yield results, the number of culms per plot and the number of kernels per spike were also determined.

The conclusions on the basis of all the data were that the competition from mustard reduces wheat yields be-

fore mustard comes into bloom. Reduction in yields are due to a reduction in tillering and also to a reduction in the number of kernels per spike.

Early spraying cannot be over-emphasized - preferably as soon as wheat reaches the 4-leaf stage. Any delay in spraying may result in heavy losses even though the delayed spraying destroys the mustard.

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USE OF CHEMICALS IN A PRACTICAL WEED CONTROL PROGRAM

E. P. Sylwester 1/

I believe it would be wise to prologue a talk of this kind with a brief summary of cultural weed control. Chemical weed control is best practiced in conjunction with, and as an adjunct to, good cultural weed control. In other words, the cultural practices of weed control are the foundation stones of any weed control program. Sometimes good, sound cultural practices of weed control have not been sufficient to keep some of our noxious weeds under control. With the best equipment the world has ever known and with typical ingenuity in the use of such equipment, coupled with the fact that the farmer now has at his disposal literally dozens of general and specific weed control chemicals, the American and Canadian farmer is in a position to very materially cut down the depredations caused by weeds. As a forerunner, then, to this discussion on the use of chemicals, I wish to point out at least a few of the outstanding cultural methods of weed control which in this chemical age should not be overlooked. You must keep in mind, that they are practices which we consider as foundation stones of weed control primarily in Iowa. However, if, from this discussion, you glean some things which may be of interest to you on your own farm or in your area, then this discussion will have been worthwhile as a forerunner to chemical weed control.

In the first place, there is the use of good rotations to help control weeds. Such rotations, when they can be practiced, will generally work to the detriment of the life cycle of many weeds involved. For instance, weeds which tend to build up in pastures and become more and more serious year after year are easily eliminated when such land is put back into clean cultivated crops. Likewise, weeds which become more and more serious in clean cultivated crops year after year are sometimes very easily controlled by the simple expedient of pasturing.

In the second place, the use of early plowing in the fall to prevent weeds from going to seed has a place in weed control.

In the third place, early and thorough preparation of the seed bed when it can be practiced is an aid to weed control. Early disking followed by repeated harrowings in advance of the time that the crop is planted, and again after such clean, cultivated crops as corn and soybeans have been planted and before they are up, and again after they are up, is one of the cheapest and quickest methods of weed control which we have at our disposal. The repeated use of the harrow, and of the rotary hoe will help make weed control work easier in many areas.

Fourth, the use of the mower to prevent weeds from going to seed. Fifth, the use of good seed, clean seed high in germination and high in purity helps eliminate weeds at the source. Sixth, the use of repeated, thorough, shallow, clean cultivation in such clean cultivated crops as corn or soybeans and the timing of such cultivations so as to do the maximum damage to the weeds.

Seventh, another method of noxious, perennial weed control is summer fallowing. Generally, we feel that this is not advisable except on areas which are just a little bit too large to treat with chemicals and a little too small to warrant the use of smother crops. Eighth, in our programs of weed control, we should not overlook the possibilities of smother crops such as soybeans, sorghum, Sudan grass, millet or heavy stands of alfalfa. Very often the use of crops such as orchard grass, bluegrass and brome grass can be used in conjunction with sprays such as 2, 4-D to drive out weedy invaders. At any rate, here is a brief survey of some cultural weed control practices that can be used with minor adaptations the country over. These cultural weed control practices form the backbone of a good weed control program anywhere and should be utilized to the fullest extent by the American and Canadian farmer. It must truly be said that the typical American and Canadian farmer with the best equipment the world has ever produced, with the best 'know how' at his disposal, that such a farmer is doing a better and better job of weed control by means of cultural practices.

As we turn to the use of chemicals, here is a fascinating field which holds wonderful promise for the weed-besieged American farmer. We have soil sterilizing chemicals. We have general weed killing chemicals. We have specific weed killing chemicals, and the end is not yet. Let me just briefly, as I have done in the case of cultural practices of weed control, review with you the wonderful ways in which these various chemicals can be used to aid you in your program of weed control. Let me enumerate some of these chemicals. They are like a wonderful kit of tools for the farmer.

In the first place, we have iron sulfate. Even though this has been quite largely replaced by other weed killing chemicals, I mention it in this area primarily because some of the pioneering work was done by one of your own great agricultural leaders, namely, Dr. Bolley. His work with iron sulfate is monumental. It started to point the way towards the day when chemical weed control would, indeed, be a reality rather than a dream. It was used primarily to control mustard in small grain. In Iowa, we used it to control dandelions and chickweed, and mustard as well as ground ivy in lawns.

Then, in addition to iron sulfate, came salt which was used for soil sterilizing purposes, salting of Canadian thistle patches, killing of barberry bushes, etc. Later, the use of sulfuric acid was developed to control mustard in the small grain. It had many disadvantages. All of these chemicals had their good points and their bad points. Later on, we had such materials as sodium chlorate and then Atlacide. These were non-selective killers and usually required two or three applications on the deep

rooted, noxious weeds. They had advantages and disadvantages. They were somewhat inflammable and certainly sterilized the soil when used in the quantities necessary to kill noxious weeds.

Then, along came such materials as carbon bisulfide and tetrachlorethane, liquids which could be injected into the soil in heavy patches of noxious weeds to kill out the deep, underground root systems. Along with these two materials came the development of chloropicrin. All these were laborious to apply and expensive. Later on, ammonium sulfamate was developed for the control of poison ivy, small brush, control of sprouts from stumps and the control of quackgrass in such areas as under well established shade and fruit trees where such chemicals as sodium chlorate and Atlacide could not be used. Ammate also lent itself to the control of weeds around house foundations, guard rails, well established trees, etc. Then, there were developed such selective sprays as Sinox and Dow Selective which, in high gallonages of water were used extensively at one time, especially for the control of mustard in small grain and flax. At approximately the same time, we had the dinitro and pentachlorophenol general killers which killed by contact and which could be used as "chemical mowers." Then, it was found that various forms of borax, either in the regular form or in concentrated forms or in conjunction with sodium chlorate, could be used for the control of noxious weeds. Then, the herbicidal oils were developed which was an indication that it was possible to selectively kill weeds in such crop plants as parsnips, carrots, caraway, parsley and dill without injuring the crop plants. Later there were developed such materials as potassium cyanate for the control of crabgrass in lawns, PMA for the control of crabgrass in lawns and the use of water-white kerosene and other oils for the control of dandelions and other lawn weeds.

This year, however, we are celebrating the birth of one of the most astounding weed control chemicals that the world has ever seen, namely, 2, 4-D. It was just 10 years ago this fall that Dr. Kephart, speaking at a small meeting of this same N. C. W. C. C. group at Omaha, announced that a new chemical had been found which would control weeds in lawns and that its full use had not been completely investigated. He talked for approximately 20 minutes on this chemical. Truly, it has been investigated further and truly it has become the miracle chemical for the control of weeds. In 2, 4-D and 2, 4, 5-T (its sister compound), farmers and homeowners found at least a partial answer to their weed control problems.

You all know the story of how this chemical has grown from a few pounds in 1944 to this past season when approximately 30 to 40 million pounds of the chemical were made and sold for weed control purposes. 2, 4-D and 2, 4, 5-T, like no other chemical, have made the farmer realize the losses that weeds have caused him for generations past. The Canadian and American farmer has taken these two materials and used them in an ever expanding weed control program. At the present time, they are used for the control of weeds in lawns, in parks, in cemeteries and in pastures. 2, 4-D can be used for the control of broad leaved weeds in small grain, corn and flax. They have the wonderful characteristic of being toxic to many broad leaved plants without being injurious to grasses such as bluegrass, brome grass, orchard grass, etc., which form the foundation stones of our lawns and pastures. They are used in ever increasing quantities for weed and brush control along county, trunk and local roads, under utility lines, along railroads, etc. 2, 4-D, in conjunction with 2, 4, 5-T, can be effectively used to control regrowth on stumps, for use in basal spraying of trees, and foliage spraying of brush. These two chemicals alone have been responsible for giving the weed-besieged farmer a new lease and a new outlook on life. They are not perfect. They have to be used with caution and they have limitations, but nevertheless these two chemicals will go a long ways towards making farming easier and more profitable.

We have made more progress in the last 10 years in all phases of weed control than we have in all the time since our pioneers landed on these shores. The time is now when every good Canadian and American farmer who is a good steward of his land need fear the tremendous depredations of weeds no more. In addition to 2, 4-D and 2, 4, 5-T, which have multiple, varied and tremendous possibilities in all phases of weed and brush control, there have also been developed such materials as CMU for the control of noxious weeds, brush and soil sterilization in such areas as around lumber yards, outdoor theaters, power stations, etc. The use of TCA for the control of quackgrass and other grassy weeds and, lately, the use of Dalapon for the control of quackgrass and other grassy weeds and all serve to illustrate how science has come to the aid of agriculture in the fight against weeds. Much needs to be done to find the exact uses, their limitations, their dosages, their total or selective killing properties.

And the end is not yet. In addition to the ones I have mentioned, there are herbicides like C. I. P. C., Oktone, Trichlorobenzoic acid, S. E. S., Sesin, M. H., Napthyl Phthalamic acid compounds, Endothal, Sodium isopropylxanthate, amino triazole, and many others. Truly the future is rosy for chemical weed control. We need only to unlock the chemical secrets. But that is a big, time-consuming task. The time is almost here when an individual farmer can look at his own specific weed problem and practically have a "tailor made chemical" to combat it if his cultural program of weed control is not sufficient. Many of these older chemicals need additional testing for other uses. Many new chemicals yet unborn will be added to our list of weed control chemicals in the future. After these materials have been truly tested and found to have valuable uses, they will be added to the "arsenal" of weed control chemicals now at your disposal.

I have tried to illustrate these chemicals by appropriate pictures of their outstanding uses. As you have viewed these pictures of cultural and chemical weed control, I hope that you have seen how these cultural and chemical weed control practices can aid you in your fight against weeds. Every farm is a little different problem when it comes to the use of cultural practices and chemicals for weed control. I hope too above all else that you have gotten a new sense of hope in your fight against weeds and, also, a better sense of stewardship of the land. If you have realized how these cultural and chemical methods of weed control can aid you in your fight against weeds, how they can make your weed control task easier and more profitable, then the mission of this talk has been accomplished. If you adopt the best known practices of weed control for your farm, you will be rewarded with the greater yields and greater profits. This, in turn, will mean a higher standard of living for you and your family.

1/ Extension Botany, Iowa State College, Ames, Iowa

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PRECAUTIONS IN THE USE OF WEED CHEMICALS

L. H. Smith 1/

My discussion today will deal mainly with chemicals that are generally used by farmers in the control of weeds and brush. Chemicals can be very beneficial in the control of weeds, but on the other hand can be very harmful if improperly used.

It is well that we first acquaint ourselves with the plant we want to destroy. For example, we have annuals such as mustard, which is a plant that does not store food and therefore does not live over, and for such plants all we need to keep in mind is to use a selective chemical that will destroy the portion above the ground always keeping in mind of course, that plants are most easily controlled during the most rapid stage in their growth and become more resistant to chemical as they approach maturity.

Then we have biennial plants such as burdock, which produce a crown the first year and a mature plant the following season. Here all we need to keep in mind is to use a chemical that will destroy the top growth. Then we have perennial plants such as field bindweed and thistles which spread by root and seed. For these we need a method that will kill both the top growth and the root system as well.

Several precautionary measures need to be taken into consideration before purchasing chemicals. Weeds generally fall into two categories, namely, grass weeds or broad leaved weeds. Chemicals may be selective in one crop and not in another even though it is a selective chemical. For example, TCA may be used to destroy grass weeds such as foxtail in flax since flax does not belong to the grass family. On the other hand, it is not possible to use TCA in oats, wheat, or barley to destroy grass weeds such as foxtail since oats, wheat or barley belong to the grass family.

Since 2, 4-D is most extensively used in the control of broad-leaved weeds and is selective in its use, it is well that you first determine whether you desire an amine, ester or a low volatile ester. For the control of broad leaved weeds in susceptible crops the amine type is most desirable since it is somewhat milder in its use. It is especially desirable since it is a chemical which lacks vapor or fumes, which is important to keep in mind when spraying near susceptible crops. However, you can have mist drift with all forms of 2, 4-D. Another factor in favor of the amine type of 2, 4-D is that if an over-dose is applied or overlapping is done less serious consequences will result. For harder to kill weeds we look to the ester formulations, especially if the crop is infested with weeds such as leafy spurge, Canada or sow thistle. We think of esters as being more effective. However, if you use an ester type remember they are more volatile and must be considered as such, and yet they can be safely used and recommended provided you have calibrated your sprayer so that you know exactly what amount is being applied. THIS IS IMPORTANT. I am quite generally prone to advise my farmers to stick to the use of amine on growing crops. However, I find many farmers with broad experience in the use of 2, 4-D who are using the esters on their crops with safety and satisfaction. I am not a chemist, so do not ask me why - but evidence shows the low volatile esters are becoming very popular among the farmers of Minnesota, namely, for the reason that they behave better. I predict that in the near future we will see a pronounced increase in the use of low volatile esters in general field use.

We must never use carry-over chemicals, especially esters, unless you have checked to see that the chemical is still in solution. After years of carry-over there is a tendencey to break down - no matter what brand you may have. Another factor which enters into the picture is the temperature. We like to spray under 70 to 85 degree temperatures. Then, too, be sure you carry the boom high enough so that you get good coverage. I personally prefer the boom somewhat higher than the generally recommended 18 inches above the weeds to be treated. Thus, if a nozzle does hesitate even briefly, full coverage is more apt to be achieved.

I must mention something about some of the other chemicals such as sodium chlorate, which is certainly an excellent chemical in the eradication of hard-to-kill weeds. Some of the cautionary measures to follow when using sodium chlorate are as follows:

1. Remember you are dealing with an inflammable chemical. I have seen tragic and pitiful evidence of this fact in my own county where an operator has been disfigured and crippled using chlorate that caught fire; deaths have also occurred.
2. It is a soil sterilant.
3. That when it is applied in solution or dry form it is safe to use. However, when it has been dissolved and dries out it becomes inflammable and therefore the sprayed area should not be walked on until dissolved into the soil.
4. Store in a dry place.
5. Do not spill on wooden floors.
6. Avoid saturating your clothes and do not use gloves.
7. Use rubbers and change clothes after spraying.

Polybor chlorate and like chemicals are excellent chemicals as a soil sterilant and are not a fire hazard. Polybor is also non-poisonous.

T C A in liquid form should be kept in a cool place if carried over. This chemical is corrosive and for this reason should not be spilled on the outside of metal containers.

The directions of the manufacturer should be followed carefully and also the recommendations for your state.

By all means put your sprayer away in the fall, but it should be cleaned first, the parts oiled and checked to see what new parts will be needed, etc. It would be well to order and install those parts before storing. The sprayer should be re-checked in the spring before using.

Keep in mind at all times when spraying to avoid drift on your neighbor's crops.

If it appears that you have crop damage, have it checked by your couty weed inspector or county agent or dealer immediately. There are times when damage may be justified in order to prevent the weeds from destroying the crop.

Last but not least, these chemicals will do just about everything that is claimed for them, but let's not expect miracles to happen. There are other chemicals I would like to mention but time does not permit me to do so.

Remember the saying - "if little is good, more is better" does not hold true when we use chemicals. That's when we get into trouble.

If you buy chemical from a barrel be sure the dealer gives you a copy of the label on this barrel. That is for your protection and Minnesota law requires labels on containers of chemicals sold.

In closing, remember before using any chemical or insecticide that you be sure that it is applied in the amount and manner as recommended. I cannot stress too strongly the importance of consulting your county agent or county weed inspector. They are always glad to help you with your problems.

1/ Cottonwood County Weed and Seed Inspector, Windem, Minn.

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PROMISING CHEMICALS BEING TESTED

Dayton L. Klingman 1/

Introduction

In 1908 Professor Bolley, working here in North Dakota, said that when chemical weed control is generally accepted that the gain will be greater than afforded by any other single piece of investigation in the field of agriculture. Now, almost 50 years later, weed control by herbicides as an accepted practice on most farms is in sight. It was in 1945, with the introduction of 2, 4-D, that great numbers of farmers became interested in chemical weed control.

With the tremendous increase in use of "weed killers" by farmers, there was a coincident increase in interest on the part of industry. It is because of industry's willingness to spend millions of dollars in the search for new chemicals that we have in sight a partial solution for many weed problems. Most of us have little realization of the great amount of time and money spent in finding promising herbicides, nor the number of chemical compounds tested and discarded for every one that is finally released to Agricultural Experiment Station workers for evaluation.

The chemicals to be discussed this afternoon are not a complete list of chemicals which show promise in agriculture. However, this group does include some of the chemicals that are being tested widely in the North Central Region, and even includes a few of the older chemicals which are demonstrating value when used in new ways or on different crops.

The data that I give and the discussion which I make are not a basis for recommendation. In most cases evaluation has not gone far enough to recommend these chemicals for field use. My discussion is to acquaint you with some of the work which is underway.

I am indebted to research personnel in the North Central Region for the material I am presenting. Time will not permit a complete review of all work, therefore I'm only going to give some of the highlights of work being done.

Dalapon (a, a-dichloropropionic acid):

The first chemical that I am going to discuss is a, a-dichloropropionic acid, commonly called Dalapon by the Company that is developing it. Dalapon was first made available to Experiment Station workers a little over one and one-half years ago. It is closely related chemically to TCA, but is considerably more active than TCA. It is many times more effective against established plants and is promising for some of our weed problems.

Dalapon is particularly effective against grasses, it is a growth regulator that is absorbed and translocated by the living plant. It is also absorbed by roots, following soil application, in much the same manner as is TCA.

Andersen, working here in North Dakota, has found that Dalapon is very effective against foxtails. Treatments with 1, 2, and 4 pounds per acre to foxtail when it was from 1/2 to 6 inches tall gave 78, 96, and 98 percent control. When the foxtail was 6 to 12 inches tall the 1, 2, and 4 pound rates gave 51, 78, and 88 percent control. In other words, at all stages of growth ranging from 1/2 inch tall to 12 inches tall a rate of 4 pounds per acre gave over 88 percent control of foxtail.

Wild oats can also be controlled. When Andersen applied 4 pounds of Dalapon to wild oats that was 2 to 3 inches tall there was 78 percent reduction in heading and 52 percent reduction in plant growth. When this same rate was applied to wild oats that was 4 to 6 inches tall there was 92 percent reduction in heads and 95 percent reduction in weight of wild oats. His research has shown further, in a separate study, that this rate of application has lowered the yield of beets only 6 percent when compared to weed free untreated beets. In Ohio, 3 pounds of Dalapon gave 96 percent control of grasses, but was not effective on the broad-leaved weeds. Later, when applied at the 4-leaf stage of beets, 2 pounds of Dalapon gave 92 percent control of grasses but no effect on broad-leaved weeds or the beets. It is not yet known whether Dalapon will be used for weed control in sugar beets, but it looks promising.

Flax was seriously injured by treatments with Dalapon in research conducted in North Dakota and in Minnesota.

In Wisconsin, Buchholtz has found that Dalapon was very promising for quackgrass control. The application of 4 pounds Dalapon to quackgrass in the spring when it is 4 to 6 inches tall, followed by plowing and preparing the seedbed for corn, has given nearly complete control of the quackgrass without injury to the corn planted immediately after the soil was prepared.

Iowa workers report 5 and 10 pounds Dalapon per acre applied to cattails when 5 inches tall gave excellent control.

Dalapon has also been effective against Johnsongrass, which is commonly found in the southern portion of the North Central Region. In general, top growth is destroyed at rates of 10 pounds or above, and a part

of the root system is killed, but there may be some regrowth appearing on the plots. A single treatment, even at extremely heavy rates, has not eradicated Johnsongrass; repeated treatments have been necessary.

A number of workers have used Dalapon for weed control in seedling stands of legumes. Workers in Illinois, Missouri, and Iowa have found that Dalapon is promising for control of grasses (including giant foxtail) in seedling stands of birdsfoot trefoil and alfalfa. They found rates from 1 1/2 to 6 pounds per acre had little permanent effect on birdsfoot trefoil or alfalfa, but injured most other legumes severely. One and one-half to six pounds of Dalapon gave excellent control of the weedy grasses and some reduction in pigweed, smartweed, and other broad-leaved weeds when applied 6 to 9 weeks after planting. Similarly, workers in Nebraska and Ohio also found that practical control of weedy grasses in alfalfa seedlings resulted from treatments of 1 to 6 pounds of Dalapon per acre applied after emergence. Weed control usually resulted in increased alfalfa stands and in Nebraska increases in yields of alfalfa in the year of seeding.

Dalapon was used for control of volunteer winter wheat in Nebraska. The control of volunteer wheat was important in areas having wheat mosaic, as these plants act as hosts to the tiny insects that spread the disease. Two pounds of Dalapon, applied August 28th, gave 100 percent control of the wheat, crabgrass, and foxtails.

Weedy bromegrasses are often a problem in the North Central Region. In Iowa and Nebraska 4 pounds per acre of Dalapon on the weedy bromegrasses in April gave complete control of the weedy bromes.

In addition to giving control of many weedy grasses, Dalapon may be injurious to many other types of plants. It is extremely injurious to soybeans, the true clovers, lespedeza, young apple trees, etc. These are just a few examples. There are many places where Dalapon cannot be used selectively, and until further work is done it will not be generally recommended. Some states may have tentative recommendations for specific uses.

Dalapon will be available commercially in 1954 for non-agricultural uses and for spot treatment in agricultural land. Two to ten pounds per acre will control annual grasses; five to fifteen pounds will kill old bluegrass sod; and twenty to forty pounds are sufficient to give good control of many of the perennial weedy grasses. It looks promising in preparing land infested with quackgrass for corn or potatoes in a number of states.

TCA (Trichloroacetic acid):

While TCA is not a new chemical, neither is it a very old herbicide, and some interesting new uses are being developed. As you know, TCA is more effective against the grasses than on the broad-leaved weeds.

Usually wild oats has not responded well to TCA. However, Andersen and Helgeson, here in North Dakota, applied TCA at 8, 12, and 18 pounds per acre to the soil in October just before fall freeze-up and disked it into the soil. In the spring these treatments gave from 87 to 97 percent control of wild oats and there was little apparent injury to sugar beets seeded in the area last spring. TCA was even more effective when used in this manner in combination with IPC. When 6 pounds each of IPC and TCA were applied to the soil in the fall of 1953, 100 percent control of wild oats resulted in the spring of '54, and no injury to beets was evident.

TCA has also given good control of foxtails in flax according to studies in Minnesota, South Dakota, Iowa, and others.

TCA is also showing some promise when used for control of weeds, especially weedy grasses, in the establishment of alfalfa and birdsfoot trefoil. In Missouri, TCA was the most promising herbicide used on birdsfoot trefoil for weedy grass control. When applied 6 weeks after planting, 8 pounds per acre gave 87 percent control of the weedy grasses. By October, stands of birdsfoot trefoil were 7 1/2 times that of the check. This treatment also resulted in stands of alfalfa over 3 times that of the check. In Illinois, 9 pounds of TCA applied 8 weeks after planting gave excellent control of foxtail, little injury to alfalfa seedlings, and some control of pigweed. In Nebraska, 5 and 7 pounds of TCA gave practical weedy grass control without affecting stands of alfalfa. By September first, the yield of alfalfa was double that of the check.

Maleic Hydrazide (1, 2-dihydropyridazine-3, 6-dione):

Maleic Hydrazide is a herbicide that has been tested by research people for a considerable time, but in just the last two or three years a use has been found for this material.

Workers in Wisconsin, Ohio, Minnesota, and Iowa have found that practical control of quackgrass is often possible by use of Maleic Hydrazide. It does not kill quackgrass rapidly, but stunts top growth and greatly reduces shoot development. Treatments of 4 to 8 pounds of Maleic Hydrazide per acre to the foliage of quackgrass, when the leaf growth reaches 4 to 8 inches in height, has given good control of quackgrass provided the area was plowed within 4 to 10 days after treatment. This is important. Plowing the area before 4 days have elapsed, or delaying the operation too long will reduce the effect materially. If the area is not plowed quarkgrass completely recovers. After plowing, a seedbed may be prepared and the area sown to various crops or vegetables without danger to the crop. This chemical is not active through the soil.

Knowles, working at the Central Experimental Farm in Ottawa, Canada, has found that Maleic Hydrazide has promise for the control of wild oats both in barley and in flax without harming these crops. Knowles, after two years' experiments with this chemical, has found that it does not kill the unwanted plants, but rather controls the wild oats by preventing the production of viable seed.

The barley, flax, and wild oats are sensitive to the chemicals at different times; therefore, careful timing is critical. On flax the chemical should be applied just after the flax has finished flowering and is 100 percent in seed boll. Do not apply Maleic Hydrazide when flax is in flower.

On barley, spraying should be done when in the dough stage. When Maleic Hydrazide was applied at the rate of one pound acid equivalent per acre in a amine formulation plus a wetting agent there was less than 1 percent germination of the wild oats, but 92 percent germination of flax and 97 percent germination of barley.

Maleic Hydrazide is not poisonous, it is not inflammable, and it is not corrosive. It is available as a water-soluble powder or in solution as an amine salt.

CMU (3-(P-chlorophenyl)-1-1-dimethylurea):

CMU and its analogs are among the more important recent discoveries in the herbicide field. They are thought of, primarily, as soil sterilants and are particularly effective for this use against the grasses. However, they are also effective against many other plants as soil sterilants. In addition, other important uses are being explored.

Most of the research workers in the North Central Region have tried CMU at low rates as a selective pre-emergence or directed spray treatment in certain crops. Buchholtz, in Wisconsin, reports that "the use of CMU or Dalapon has generally been the most promising pre-emergence application that we have for weed control in corn." In Ohio, Willard also reports that CMU does a remarkable job on corn, although it requires 4 pounds to the acre on high organic soils. Because of the great danger of accumulation in soils, especially in the northern region, it should not be recommended for the present. In Missouri, Fletchall got good weed control when CMU was used pre-emergence in corn at 1 1/2 pounds in 1953, but applications of 2 pounds per acre in 1954 resulted in approximately 60 percent reduction in corn stand.

Holm, of Wisconsin, working with Horticultural crops has found that 2 1/2 pounds CMU on both sides of newly planted apple and cherry trees has given excellent weed control, and in 4 years have given no injury. Also, two pounds CMU, applied pre-emergence, for gladiolus and asparagus have given good weed control and no injury to these crops. Also, combinations of 1/2 to 3/4 pound CMU with other chemicals, such as CIPC, TCA, Endothal, and Alanap, for pre-emergence in vegetables look very promising in beans, beets, carrots, and onions.

In Nebraska, 5 pounds CMU plus 1 pound 2, 4-D applied on irrigation ditches and laterals gave 85 percent control of all weeds. When 10 pounds CMU plus 1 pound 2, 4-D was applied, 95 percent control resulted.

Lee, in Indiana, applied 10, 20, and 30 pounds of CMU to Johnsongrass which destroyed all the top growth and prevented all growth during the summer and fall. Twenty pounds and more applied in 1952 has prevented Johnsongrass growth as well as the growth of crops of corn and soybeans planted each year in 1952, '53 and '54.

Rates as low as 15 pounds per acre have given almost complete control of oak brush.

One of the advantages of CMU as a soil sterilant is its long persistence in the soil. Its persistence in the soil may also be a handicap for its use on crop land. If it should accumulate in agricultural land it would be serious. This factor has not been fully evaluated as yet and for that reason it will not generally be recommended for use in the North Central Region on crop land until more time for its evaluation has elapsed.

Amino Triazole (3-amino-1, 2, 4-triazole):

Amino Triazole is an interesting chemical in that treated plants are often completely white. Amino triazole is a translocated herbicide that prevents chlorophyll formation. The exact potential of amino triazole is not yet known, although it shows promise for certain uses.

Willard, in Ohio, indicates that in preliminary tests it is the most important thing we have seen on Canada thistle, but hastens to add that their results are excessively preliminary. Lee, in Indiana, indicates that Canada thistle was treated at 2, 4, and 8 pounds to the acre in the spring when the Canada thistle were from 3 to 15 inches tall. By October, over 99 percent control had resulted. Upon excavation there was still some portions of the root system still alive, but did not appear as healthy as those found on untreated plots. Iowa workers also report good kills of Canada thistle.

Amino triazole appears to have promise for control of quackgrass. Eight pounds applied to the foliage in the spring followed by plowing 4 to 10 days later has given good results in Wisconsin.

IPC (isopropyl-N-phenylcarbamate) and CIPC (isopropyl-N-(3-chlorophenyl) carbamate):

IPC and CIPC are not new chemicals, but some new and interesting uses are being developed in the North Central Region. Shebeski and Burrows, University of Manitoba, have found that 10 pounds emulsifiable IPC sprayed and disked into the soil in October for wild oat control gave virtually complete control of the wild oats. Spring planted crops in this soil showed the following crops unaffected by treatment: sugar beets, alfalfa, soybeans, corn, peas, sunflowers, and rape. Some injury resulted to flax and severe injury to the small grains and bromegrass.

Andersen and Helgeson, in North Dakota, also applied IPC to the soil, and disked the material into the seedbed. They applied 8, 12, and 18 pounds per acre in October and these treatments have given from 81 to 91 percent control of wild oats with no apparent injury to the sugar beets planted the next spring.

Various workers have indicated that CIPC was finding commercial use on onions as a pre- and post-emergence treatment at from 4 to 8 pounds per acre. This treatment is particularly good on smartweed and purslane.

DNBP or dinitro (4-6-dinitro-o-sec-butylphenol):

The dinitro materials are not new, and have been used in this country since in the 30's; however, again some new uses are being developed. Willard observes that "Really the most exciting new chemical is the old one, dinitro on corn. For the third year now we have had very successful results with it, and it certainly does a lot of things that 2, 4-D won't. I think that that is one of the most important near future developments."

When applied at the coleoptile stage, 3 pounds gave over 97 percent weed control; when applied a week later, 4 to 5 leaves, 2 pounds gave over 85 percent control. Apparently, effective grass and broad-leaved weed control can be obtained with low rates of DNBP for a period of at least 10 days following corn emergence.

Many workers have found that DNBP gives fair to good control of most of the broad-leaved annual weeds and fair to good control of weedy grasses when applied pre-emergence to soybeans.

3, 4-D (3, 4-dichlorophenoxyacetic acid):

Only a limited amount of work has been done with this chemical. 3, 4-dichlorophenoxyacetic acid is closely related to 2, 4-D. Ohio reports that 1/4 pound 3, 4-D gave good broad-leaved weed control with no harm to alfalfa or oats when applied either 3 days after seeding or at the 2- to 3-leaf stage of the alfalfa. 3, 4-D is less toxic to the legumes than 2, 4-D or MCP.

2, 4, 5-TP or Silvex (2(2, 4, 5-trichlorophenoxy) propionic acid):

Another growth regulator, that is not new but is finding a new use, is that of 2(2, 4, 5-trichlorophenoxy) propionic acid. This material has been used for several years by horticulturists. It is showing considerable promise for the control of oak trees where they are a problem. Work indicates that it may be slightly the most effective chemical available for foliage spraying of oak. However, there is evidence that it is not any more effective, if as effective, on many other species of woody plants.

Conclusion

The discussion just given does not include all of the chemicals which are available for trial in weed control, nor does it claim to be a comprehensive list of the chemicals showing promise. It does include many of the chemicals of greater interest in the northern part of the region. Neither does the work mentioned include all the work done with any chemical, it is only a small sample of that being done in the area.

Great progress in the use of chemicals for weed control on farms is being made. Most of the herbicides are planned to increase the efficiency of our weed control job. The use of herbicides gives us another tool to supplement cultural practices, and in many cases the herbicides do a job not found possible to do by cultural treatments. However, where cultivation does the weed control job satisfactorily it probably will continue to be the most widely used and perhaps most economical weed control method.

1/ Field Crops Research Branch, USDA, Missouri Agricultural Experiment Station, Columbia, Missouri

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WILD OAT CONTROL ON MY FARM

P. P. Dunn 1/

In considering the problem of wild oats and their control it might be well to look back several years for some clue to the rapid headway they have made to now rate as our No. 1 weed. Going back to 1920, our farm had some wild oats but sow thistle held the spot-light, with ragweed and wild mustard next in importance. Most attention was centered on sow thistle with intensive tillage being the method of control. Intensive cultivation no doubt provided the wild oat with ideal conditions to get firmly established. This was the pattern until the early 1930's when drought and grasshoppers did a much better job of eradication of the sow thistle than we were able to do.

As a farmer I find it hard to estimate the loss due to wild oats as they are generally patchy. We have lost heavily on more than one crop of flax, and many of wheat that should have yielded up to 30 or 35 bus. per acre, with some parts of the field having practically no crop at all. Wild oats must be induced to grow before they can be killed. We have found that the wild oat preferred company and did much better on land that had been well prepared for cereal crops. This then gave us the idea that a well prepared seed-bed planted in the early spring to tame oats for green feed would provide the necessary condition to induce the maximum number of wild oats to germinate. This crop was harvested sufficiently early to make sure that wild oat seeds did not mature. The field was summerfallowed for the balance of the season.

Where a field so treated was pastured we found that cattle were almost sure to leave some heads to ripen. These, though few, were cut with the mower. We have found it a good plan to plant our grass and legume seed along with the green feed. After the feed is cut, if growth is sufficient, the field may be pastured. In this way the grass is given plenty of time to become well rooted.

In my opinion livestock can play a very important part in the control of the wild oat. The portion of the farm to seed down is a matter for the individual to decide. On our farm of 600 cultivated acres 200 acres are seeded to grass and legumes. Unless something unforseen happens we plan on keeping about one third seeded down.

In any program of control the weather always plays a major part. Wild oats just will not grow when it is either too dry or too wet. The type of implement to use is also something to consider. We firmly believe in surface cultivation, which keeps the seeds near the surface where conditions are more favorable for their growth. We have found either the disk-tiller or wide level-disker with seeder attachment very successful for seeding. In this way the seed is placed in moist earth leaving the top soil to dry out. At the same time the wild oats that have already germinated are killed.

Surface cultivation soon after the crop is harvested has in some years started a heavy growth of wild oats but this plan, even though it sounds good, does not always work.

North of the Border any wild oats that have started to grow but have not reached maturity before freeze-up will cause no further trouble. The frost will see to that. Since taking the problem seriously in hand we have had some success in wild oat control. On one field very heavily infested with wild oats, we seeded tame oats two consecutive years for pasture using surface tillage methods. In the fall of the second year we plowed the field to a depth of about five inches; last spring wheat was seeded. A very clean crop was grown which yielded 30 bushels of No. 2 wheat per acre.

Another field, where sweet clover was left for seed last year, was plowed last fall, disked and harrowed in early spring and left until about June 29th when barley was seeded with a disker. This field yielded very well

and was reasonably free of wild oats. The above plans as followed on my farm have definitely stopped the advances of the wild oats and the effort has been really worth while.

To look ahead we can forsee many benefits from a program of good tillage combined with livestock, which in our case is beef cattle. Soil fertility will be maintained and we hope increased by the use of grass and legumes. The value of the barnyard manure should not be underrated. Clean seed should not be overlooked. It is fundamental to any weed control program.

In closing my remarks, a word to the wise -- Any plan or program of controlling the wild oat must first be practical. It must be economical in its application. It must show a potential profit. Lastly it must be acceptable to the average farmer.

1/ Oakbank, Manitoba

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CANADIAN THISTLE CONTROL

Ralph Diehl 1/

Folks, my part on this panel deals with my experience with eradication and control of Canadian thistle. From the start I want to point out that because of variations in crop rotations my pet method of control may not be practical in all areas represented in this conference. It would be practical, however, all up and down the Red River Valley where summer fallow is a common practice.

My method consists simply of a good job of summer fallow. After the grain crop is taken off in the fall I till the soil once or twice with a spike tooth deep tillage tool. The following year about June first the moldboard plow is used. As soon as green foliage begins to appear the deep tillage tool is again used at a depth of about six inches. This implement is continually used throughout the summer and fall at intervals of 10 to 14 days and in varying directions. About 9 deep tillage operations following the moldboard plow are performed. Success depends upon how religiously you perform the tillage operations never letting other work interfere.

About 8 years ago I purchased a quarter section of land completely infested with Canadian thistle. I applied this method to half the quarter the first year and to the other half the second and I can truthfully say I haven't found a Canadian thistle since. Incidentally there was a small patch of leafy spurge in one field which was also completely eradicated.

Neighboring farmers in my county report other experiences. One worked his field until July first then seeded Siberian Millet and claims complete eradication. Another claims eradication by mowing at bud or early flowering stage. Still another boasts control for 5-6 years by planting rye two years in succession. Chemicals are being tried with varying degrees of success. Further trial and error experimentation by farmers will undoubtedly uncover other successful ways of control or eradication of Canadian thistle by chemicals.

I believe we can conclude that whatever method is used, management plays a very important part. Then too, we have the elements of weather to contend with. This factor will spell failure of any plan in certain years.

1/ Hillsboro, North Dakota

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WEED CONTROL ON THE FARM

Walter Trende 1/

I own and operate a 240 acre farm in the northeast corner of South Dakota. It is necessary to get every acre to produce the maximum in these days of high cost of farm operation.

My farm is right in one of the heaviest sow thistle infested areas in South Dakota. This is how I have successfully controlled sow thistle on my farm.

Before the combine came into the farm operations sow thistle control wasn't a problem as the sow thistle was easily controlled in the small patches here and there. But as the sow thistle began to spread and infest entire fields my farm was no exception. Summer fallow was out of the picture as the soil on my farm is of a sandy loam and we have considerable blowing and drifting of top soil. My only solution was a good crop rotation and the use of 2, 4-D. In the infested areas I planted crops such as oats, barley and wheat that could be sprayed at a rate sufficient to control the sow thistle. I have found that it is necessary to spray in the fall after harvest when the sow thistle shows a good vigorous growth using an Ester 2, 4-D at the 3/4 lb. of acid per acre and waiting to fall plow for at least three weeks after spraying.

Perhaps the greatest factor in my success in controlling sow thistle has been the use of the hand sprayer in the areas that are badly infested. I go in and spray, sometimes as many as 4 times during the crop season to prevent regrowth and seeding of the sow thistles. When crop spraying, I have always used a sufficient rate of application of 2, 4-D even if it meant crop damage. I would rather sacrifice the crop than spare the weeds as in most cases you don't get a crop if you have weeds. This has given me 100% control. My method of sow thistle control has been:

1. Good tillage practices
2. Suitable crop rotations
3. Maintaining high soil fertility

4. Use of chemicals
   A. Using Amine 2,4-D at 1/2 lb. per acre in crop spraying.
   B. Fall spraying using Ester 2,4-D at 3/4 lb. per acre rate of application.
   C. Spraying the small, heavy infested patches three or four times during the crop season, if necessary, using a hand sprayer.

1/ Rosholt, South Dakota

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WEED CONTROL ON THE FARM

Frank L. Mitchell 1/

The problem of weed control must first be recognized and one must be able to see the weeds and to identify them. How can weed control on the farm be done?

Weed Prevention

Clean Seed: In a drill box survey made in 1954 by the Minnesota Crop Improvement Association, we again proved that "as we sow, so shall we reap". The survey was made in three west central Minnesota counties. The samples of seed were taken from the drill box as the farmer was seeding in the field. Forty-five samples were collected, all representing the farmers' own seed, of which 70% was grown and 30% purchased. We find that 32 samples contained 53 wild oats per lb., 28 samples contained 28 wild mustard per lb., 23 samples contained 65 wild vetch per lb., 14 samples contained 14 quack grass per lb., and 37 samples contained other crops, an average of 125 non-crop seeds per lb. of seed. A total of ten samples contained restricted weeds in excess of the State Weed Law.

Certified Seed: By planting adapted Certified seed a farmer automatically takes care of one important phase of the weed problem by not seeding weed seeds on his farm. In Minnesota, Certified seed can contain a maximum of three restricted weed seeds per lb. while no prohibited or noxious weed seeds are permitted. In addition to this, the farmer planting Certified seed knows the seed he is planting is true as to variety and that the seed is of high purity and germination. Compare this then with the drill box survey just mentioned above and I am sure we will all agree that the small additional cost of planting Certified seed on our farms can be justified. Putting it another way, Certified seed is inexpensive when all factors are considered and low quality seed is the most costly. We have been producing Certified seed since 1938.

Crop Rotations: With a good crop rotation system many of our common weeds can be controlled. With the assistance of the Extension Service in Minnesota, we set up a crop rotation system fifteen years ago. Our major rotation consisted of five fields with two corn, two grain and one alfalfa-brome. We have found that by leaving the alfalfa-brome down two years we are able to get to all the fields in a relatively short time and this greatly assists in building fertility and at the same time holds the common weeds in check. We have changed the rotation to meet the conditions of today and we now have two fields of corn, one of soybeans, one grain (seeded to alfalfa-brome every other year) and the other field to alfalfa-brome for hay or pasture. This change has assisted in better weed control and increased our income. By following the soybeans with grain-alfalfa-brome seeding we get increased yield and less trash for the following hay crop.

High Soil Fertility: By using commercial fertilizers to balance available plant food in the soil, experiments have proved that better stands of all crops can be obtained. With increased plant population, many of our more common weeds are smothered out.

Weed Eradication

Machinery: Over a period of time machines have been developed that are very effective in the eradication of some of our noxious weeds. With the heavy equipment available today weeds such as quack grass, for example, are more easily controlled. Of course, timing is important.

Chemicals: Following World War II, the use of chemicals for weed control and eradication has become widespread. We first used Sinox for broadleaf weed control in oats in 1946. This was the first any chemical weed control work had been attempted in our county and was pretty much experimental. However, the results were very good considering the nature of the chemical and our limited experience with it. This was only the beginning and with the newer chemicals, 2,4-D amine and esters, and later MCP, we have increased our use of these until now the past year we applied spray material to all of our small grain, flax, and corn acreage. Flax was sprayed at about 4" height and the small grains when about 6" to 8" in height. Corn was sprayed when under 10" if the entire field was covered or when over 14" if sprayed between the rows using corn drops. In addition, we have sprayed all the fence lines every year.

The one quarter we purchased in 1941, had been poorly farmed and was infested with many broadleaf annual weeds and a few Canadian thistles. In order to more easily produce Certified seed we have continuously used 2,4-D amine at the rate of 1/2 pound of actual acid per acre on the cereal grains and 1/4 pound of MCP per acre on flax. The past year when we seeded non-hardy alfalfa with all our grains and flax, we used only MCP at the rate of 1/4 pound actual acid per acre. We find the MCP is not so injurious to the alfalfa.

After using and experimenting with several types and makes of sprayers, we purchased a new sprayer in 1949. This machine has given us satisfactory results. We have sprayed over five thousand acres for ourselves and our neighbors in the past six years, using the 2,4-D chemicals, MCP, and TCA for weed control and the insecticides DDT, Chlorodane and Toxaphene for control of

cutworms in corn and for control of bugs and insects in alfalfa for seed production. We have had no loss from overspraying. This is no accident or good luck. It is merely the result of careful handling, measuring and timing. All chemicals and water are strained into and out of the sprayer tank. The chemical is added as the tank is being filled. I use a quart fruit jar and carefully measure the chemical used. The material in the tank is agitated a few minutes before I start in the field. My machine is set so that with ten gallon nozzles, I drive 5 miles per hour with the tractor and actually apply 10 gallons per acre. At the 5 mile per hour speed and 40 pounds pressure and the 35 foot boom, one acre can be covered in three minutes and the entire load will cover twelve acres in 36 minutes. The Extension Service has developed an easy way to calculate the amount of water being used by any machine.

We fall plow immediately after harvest to assist in the weed control program.

As Town Clerk, I have worked with the Town Board in my Township and in turn with the County Board and our County Weed Inspector in the control of weeds in our community. Several times we have had to serve Form 1 and Form 5 to get some of our farmers to co-operate. As farmers continue to recognize that effective weed control can be achieved only by the co-operative effort of all the farmers, faster progress will be made. Two years ago at the North Central Weed Conference at Winnipeg, Canada, our County Weed Inspector, A. T. Olien, was recognized for outstanding weed control work in Minnesota. He is now District Weed Inspector. I expect our new inspector will be just as good in a few years.

Summary

1. A high percentage of the weeds we find in our fields are seeded by the farm operator.

2. Certified seed has a place in a weed control program.

3. A good crop rotation system and a high soil fertility program will be of great benefit in any weed control program.

4. Power machines are effective.

5. The many chemicals we have today are designed for a specific purpose. Wise use of them is very important.

6. This vast weed program headed by our alert State Weed and Seed Department and assisted by an efficient weed and seed inspector in every county in Minnesota, can succeed only with the fullest co-operation of our Extension Service, County Commissioners, Town Boards, villages, and the farmers in general. We still have work to do and it can be done.

1/ Canby, Minnesota

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SHEEP PICK WILD OATS FROM FLAX CROP

Wm. R. Page 1/

Page Farms, Hamilton, N. D. have demonstrated that sheep can do a good job of selectively grazing wild oats, and certain other weeds too, from a growing flax crop.

John F. Page, member of the Page Farms group, was informed by the writer that the May Bros. of Oberon, Manitoba reported successful use of sheep in grazing wild oats from flax. When in May 1954, a 70 acre field of B 5128 flax seeded May 11-12 produced a threatening stand of wild oats he decided to try out the "sheep idea."

Eighty Shropshire ewes with seventy spring lambs were turned into the flax when it was about two inches high. The following weeks of wet weather kept the field quite muddy but trampling damage to the flax was negligable. Sheep nipped off the wild oats, mustard, pigweed and wild buckwheat and ate flax plants only by accident. The only place flax was eaten was in extremely dense stands of wild oats where competition ruled out any chance for flax, regardless. A 2,4-D and TCA combination spray held a heavy stand of pigeon grass and some wild mustard in check.

Careful examination by the writer revealed a normal stand of six to eight wild oats per square foot in much of this 70 acre field. These were eaten off close to the ground while flax grew apace. Roughly one or two plants per square rod escaped the sheep to produce seed. Most of these plants were noted growing in the flax row where sheep missed them.

Since the 70 acre field produced too much grazing for the flock, plenty of oats grew and went to seed in the farther reaches of the area. Maybe 20% more sheep would have properly grazed the whole field. However, there is the possibility that too close pasturing would result in some eating of flax. The sheep were allowed access to the flax until past the half-blossom to half-boiled stage.

In another later seeded flax field several areas of wild oats grew ahead of flax because plants were not killed when seed bed was prepared during damp weather. A herd of twenty Jersey cattle were turned in. They quickly learned to seek out the wild oat areas and did a good job of control without apparent offset damage to flax. They were in the field only one week but 50 yearling sheep, and the breeding flock above, grazed in this field on a come and go basis for at least 2 or 3 weeks. Practically a perfect job of oat control resulted. Some trampling damage was noted along a headland that appeared to be caused by cattle. This could not be certain since observation was made several weeks after stock were removed from the field.

1/ Grand Forks, North Dakota

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REGULATORY COMMITTEE REPORT

FEDERAL LEGISLATION CONCERNED WITH

FEDERALLY OWNED OR CONTROLLED LANDS

Chas. J. Gilbert 1/

Companion bills were introduced in the 83rd Congress by Senator Mundt of South Dakota and Congressman Lovre of South Dakota asking for mandatory control of noxious weeds on Federally owned or controlled lands as required of farmers of the various states in which such lands were located. Because of opposition of the Director of the Budget, the Senate bill was never called up by the Chairman for a hearing. The same lack of action resulted as to the House bill because of opposition expressed by the U.S.D.A. and other federal agencies to the House Agricultural Committee and its Chairman.

When we never even have a chance to tell our story because of opposition of Federal agencies who are opposed to doing the logical, right, and proper thing, we haven't much chance.

However, when the House Agricultural Committee made its widely advertised trip over the country and made one of its stops in South Dakota, we pulled strings to the extent that two of us were able to get considerable data to the Committee--if they were so minded as to use it. However, the big question that developed at that hearing was in regard to firm and flexible crop supports and we were submerged by farm groups presenting many witnesses for and against these plans.

In this case the Committee cannot be too much criticized, but I am still of the opinion that we nor our cause have not been properly recognized by Congressional Committees or agencies in attempting to solve this most critical problem.

This is not a satisfactory report as to legislative progress. We can report, however, that because of our interest and activity and perhaps because of the threat of pending legislation, we have had some increased cooperation from certain agencies. The military installations under the direction of Mr. Shatwell continue to be our best federal cooperator. We have had increased cooperation in varying degrees from the Indian Service, Fish and Wild Life Service, Forestry Service, and Reclamation Service.

This is not the time to stop asking for cooperation in this matter. Perhaps it is desirable at this time to have congressional delegations from other states introduce and sponsor this legislation. It is certainly proper that other bodies join us in this effort.

Thank you.

1/ State Weed Board, Brookings, South Dakota

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RECOMMENDATIONS OF THE RESEARCH COMMITTEE

OF THE N.C.W.C.C.

The following recommendations and suggestions were prepared in advance of the 1954 Conference by the Research Committee of the North Central Weed Control Conference. The information contained here represents the combined efforts of most of the research workers in the Conference area in addition to the Committee members themselves. It should be recognized that climate and edaphic factors vary considerably from east to west and from north to south and results obtained from a specific practice may also vary. Control measures contained in these Recommendations cannot replace local recommendations. Specific recommendations should be obtained from your state agricultural experiment station, extension service, or regulatory officials. Recommendations for the use of a particular chemical is subject to approval by the Pure Food and Drug Administration. Use of a chemical on crops other than those indicated should be avoided.

Chemical names, chemical abbreviations, and definitions of terms are all given in the Report of the Terminology Committee of the NCWCC.

CONTROL OF HERBACEOUS PERENNIAL WEEDS

Systematic and well planned use of cultural or chemical methods or a combination of these methods will eliminate the most persistent perennial weeds. Regardless of the method used to eliminate the old stand, however, seeds in the soil will germinate and produce new plants. The seedlings of most of the broad-leaved species discussed below can be controlled with 2,4-D.

Cultural Control

Intensive cultivation will eliminate a high percentage of many perennial weed species, but increases the hazard of erosion. For field bindweed, Canada thistle, perennial sow thistle, leafy spurge, Russian knapweed, hoary cress, Johnson grass, bur ragweed, horse nettle, toadflax and bladder campion, the first operation should be at a depth of 4 to 6 inches with a moldboard plow or one-way (wheatland) disk, depending on the area and soil conditions. Quackgrass should be tilled at a depth of 2 or 3 inches with a spring-tooth harrow or one-way disk--if a plow is used, the plowed sod must be cut up with a heavy disk. The first operation of the year should be performed about 2 weeks after the weeds emerge in the spring for the broad-leaved weeds, and about July 1 for quackgrass and Johnson grass. However, the effectiveness is often increased for leafy spurge, hoary cress and toadflax if tillage operations are begun the previous fall; and defoliation by close clipping or grazing prior to the first cultivation of Johnson grass or quackgrass is also very helpful for controlling these weeds.

Succeeding cultivations should be performed about one week after weeds emerge (2- or 3-week intervals) for the broad-leaved weeds and when regrowth is 4 to 6 inches long for Johnson grass or 2 to 3 inches long for quackgrass. Cultivations should be continued until freeze-up unless a competitive winter crop is seeded. A field cultivator equipped with wide overlapping duck-foot sweeps operated at a depth of 4 inches is the preferred implement for use on all species listed, except quackgrass where a spring-tooth harrow or a field cultivator equipped with

spring shanks and bull-tongue points (shovels 1" to 2" wide) operated at a slightly lower depth for each successive cultivation is the preferred implement. Rhizomes should be brought to the surface where they are desiccated by the weather. However, a one-way disk may be used on bindweed, the thistles, and quackgrass or for the second operation on leafy spurge, hoary cress, and toadflax.

One year of intensive cultivation will generally eliminate 95% or better of Canada or perennial sow thistle and a like amount of quackgrass or Johnson grass during a dry year. A second year will usually eliminate the remaining plants of all listed species except toadflax. In many cases, where broad-leaved weeds are involved, it is desirable to seed a small grain crop and spray with 2,4-D instead of a second year of cultivation. A competitive crop of sudan grass has been effective on spurge.

Competitive winter grain crops, such as winter wheat or rye, alternated with intensive cultivation is more practical than intensive cultivation alone, for eliminating field bindweed, leafy spurge, Canada thistle, perennial sow thistle, Russian knapweed, hoary cress and Johnson grass. The land should be intensively cultivated as outlined above from spring until the crop is seeded. After the crop is harvested, the field should be cultivated intensively until the second crop is seeded. Several years are generally required to give complete elimination. Spring sown barley handled in a similar manner also has been effective on bindweed and toadflax, but ineffective on spurge. However, it leaves the area bare over winter which is conducive to erosion.

Summer crops, such as forage sorghum, sudan grass and soybeans, when used in conjunction with intensive cultivation, are effective for the control of field bindweed, Canada thistle or perennial sow thistle. Sudan grass is effective on leafy spurge, while buckwheat, proso millet, German millet and late sown barley are helpful for controlling quackgrass. The land should be intensively cultivated until June 1 to July 1, depending on latitude. If sufficient moisture is available, the crop best adapted to the location and for controlling the weed should be seeded at a heavy rate with a grain drill. The crop should be harvested for forage, except proso millet and buckwheat which may be harvested for seed. After harvest, cultivation is continued until freezeup. If there is not sufficient moisture in May or June to warrant seeding a crop, intensive cultivation can be continued all season.

Perennial forage crops give a high degree of control of several species of perennial weeds especially when preceded by a season of intensive cultivation. Alfalfa alone or in a mixture with an adapted grass will generally eliminate 95% of Canada thistle or perennial sow thistle in 3 years or a similar percentage of field bindweed in 5 years and will prevent the spread of quackgrass. Alfalfa also is effective for controlling Johnson grass, but should be mowed more frequently than the optimum for normal alfalfa hay production. Grasses seeded alone enhance the effectiveness of 2,4-D on bindweed, the thistles, spurge, knapweed and toadflax. One season of intensive cultivation followed by fall seeded bromegrass, which is sprayed twice a year for one or more years, depending on species of weed, will eliminate 99% of the weed and yield a hay crop the first season. If cultivation does not precede the seeding of the grass, 3 or 4 years of spraying will be required to effectively reduce the stands of leafy spurge, knapweed or hoary cress. Frequently, the spraying does not eliminate these weeds and it is necessary to follow up with a year of intensive cultivation.

Late fall tillage is an effective method of controlling several species of weeds. Deep plowing immediately before freezeup generally reduces the stands of field bindweed, Canada thistle or perennial sow thistle. In some cases thistles have been completely eliminated by this single operation. Shallow cultivation of quackgrass and Johnson grass in November exposes the rhizomes to freezing and is effective in reducing the stand and retarding spring growth, especially if preceded by a season of close defoliation by grazing or mowing.

Grazing is an effective method of eliminating field bindweed or leafy spurge, although it may not be practical in the eastern part of the region. A winter annual crop, such as winter wheat or rye, grazed with sheep from spring until the crop starts to head. The sheep are then put on supplementary pasture, the rye is plowed under and the land is reseeded to a summer crop, such as sudan grass, which is grazed as soon as it has sufficient growth. A second crop of rye is seeded in the fall and may be grazed or harvested the following year. Afterwards the land should be cultivated intensively until fall.

The use of sheep has proved to be a practical method of controlling large infestations of leafy spurge on untillable land. The degree of control is dependent on the intensity of grazing. Grazing should begin in early spring and continue all season. If sheep do not keep the grass down, cattle may be rotated ahead of them.

Continuous, close grazing reduces the vigor of quackgrass and Johnson grass and results in the rhizomes occurring relatively shallow. Lespedeza may be sown in Johnson grass to increase the carrying capacity of the field for summer pasture. There is some danger from prussic acid poisoning to ruminants grazing Johnson grass.

Chemical Control

Field Bindweed (Convolvulus arvensis L.)

Applications of 0.75 to 1 lb./A of 2,4-D will control this weed under most conditions, but 0.50 lb. is often sufficient on cropland. Satisfactory control is obtained by applying 2,4-D at the bud to bloom stage of growth or in late fall. In dry areas, best results are obtained by applying an ester at the pre-bud to bud stage of growth. However, effective control has been obtained on fallow land by cultivating in the spring and spraying after allowing the bindweed to come into the bud or early bloom stage of growth.

Small patches of bindweed may be eliminated by the use of soil sterilants. Sodium Chlorate, at the rate of 5 to 6 lb./sq. rd. (800 to 960 lb./A.), or the borate-chlorate mixtures, at the rate of 8lb./sq. rd. of active ingredient (1280 lb./A.), consistently eliminate this weed. Borax compounds, at the rate of 10 lb./sq. rd. of boron trioxide equivalent (1600 lb./A.), also are often effective in eliminating bindweed. When plenty of soil moisture is available CMU is effective at the rate of 0.5 lb./sq. rd. of active ingredient (80lb./A.). CMU should be used on non-crop land, only. After use of any of the soil sterilants, spot treatments may be necessary to eliminate scattered remaining plants.

Leafy Spurge (Euphorbia esula L.)

2, 4-D is effective in controlling leafy spurge. Top growth can be retarded and the setting of seed can usually be prevented by application of 0.5 lb./A. of an ester before the upper bracts begin to turn yellow. However, two or more applications per year of 1 to 2 lb./A. of an ester for several years are required to approach elimination. Fall or early spring applications of 40 lb./A. of 2, 4-D amine will usually give complete elimination of leafy spurge in the western states of the region. Rates as low as 20 lb./A. are effective on sandy soils.

The use of 2, 4-D in conjunction with cultural practices has proved to be a practical system for the control of this weed. Summer tillage (after harvest) followed by intensive cultivation until freezeup with an application of 1 or more lbs./A. of 2, 4-D ester after spurge emerges in the spring followed by 4 cultivations applied when regrowth occurs will often eliminate 99% of the original stand in one year. Likewise, intensive cultivation for one year followed by a spring sown crop of wheat or barley, which is sprayed with 0.5 lb./A. of an ester and followed by intensive cultivation until freezeup, will eliminate leafy spurge if the second year's program is continued over a period of 4 or 5 years. On rough or stoney pastures a proven system is to apply 2 lb./A. of 2, 4-D ester at the bud stage of growth and retreat in the fall. The next spring nitrogen is applied to stimulate the grass and the pasture is grazed moderately. The weeds are controlled but several years are required to give appreciable elimination.

Soil sterilants can be used to eliminate small patches of leafy spurge. Borax compounds will generally give complete elimination when applied at the rate of 5 to 6 lb./sq. rd. of boron trioxide equivalent (800-960 lb./A.) between July 1 and November 1. Similar rates of sodium chlorate or ammonium sulfamate and a like amount of active ingredient contained in borate-chlorate mixtures will give complete elimination when applied in early fall, but higher rates are needed in the summer. After treatment with any of the soil sterilants, spot treatments may be necessary to kill remianing scattered plants.

Quackgrass (Agropyron repens)

Use of chemicals is promising for control of quackgrass under a number of circumstances. Applications of from 20 to 40 lb./A. of TCA will control quackgrass in humid regions when the application is preceded or followed by a thorough tillage or plowing. Elsewhere from 50 to 75 lb./A. are required. From 80 to 120 lb./A. of TCA are required for control on untilled sod. Dalapon (2, 2-dichloropropionic acid) gives results similar to those obtained with TCA. In humid regions it appears to be more effective than TCA when applied to quackgrass with well developed foliage. Soil applications or applications to areas with scanty foliage will require rates similar to those used with TCA. Late summer and fall applications of the heavier rates of TCA or Dalapon are likely to leave a soil residue during the next growing season.

Sodium chlorate may be applied at any time, though probably best in the fall when rainfall is moderate, at 2 to 4 lb./sq. rd. (320 to 640 lb./A.). In sub-humid regions such applications are likely to leave a residue toxic to crop growth during one or two growing seasons. CMU may be used for eradicating quackgrass on non-crop land. Complete or nearly complete kills are obtained by use of from 20 to 40 lb./A. with early spring or late fall treatments being the most effective. Normal growth of crops on the treated areas should not be expected for at least two years.

In humid regions effective control of quackgrass can be obtained by early spring foliage applications of 4 lb./A. of MH followed in 4 to 8 days by plowing. Best results occur on fertile soils or following fertilization of quackgrass with nitrogen to ensure a good shoot growth. Crops may be planted as soon as soil preparation is completed for MH does not leave a toxic residue in the soil.

Canada Thistle (Cirsium arvense L.) and Perennial Sowthistle (Sonchus arvensis L.)

2, 4-D is slightly more effective than MCP and considerably more effective than 2, 4, 5-T on these thistles. Sowthistle is somewhat more readily controlled than Canada thistle, provided ester formulations are used. Usually at least two applications of 2, 4-D each year over a period of two or more years are necessary to eradicate these weeds. The first application each year should be made at the early bud stage, and one or more treatments made later in the summer and/or early fall. Rates over 1 pound per acre tend to be less effective than is 1 pound. Good control required spring or early summer treatments followed up by late summer and/or fall treatments. The early treatment should be 2, 4-D applied in the crop, but the late treatments may be, in order of effectiveness: (1) cultivate intensively from harvest until freezeup; (2) plow after harvest and spray thistles after they emerge; (3) spray when rosettes are formed and late fall plow; or (4) spray when rosettes are formed. Sodium chlorate gives good control at 3 to 5 pounds per square rod (500 to 800 pounds per acre), though retreatments are usually needed for eradication.

Russian knapweed (Centaurea repens L.), Hoary Cresses (Cardaria spp.) and Bur ragweed (Franseria discolor and Franseria tomentosa)

The cultural practices discussed at the beginning of the herbaceous perennial weeds section also apply to these weeds. Where possible a control program should make use of the combined beneficial effects of crop competition, herbicidal sprays and intensive cultivation.

Russian knapweed (Centaurea repens L.)

Russian knapweed is quite tolerant to 2, 4-D. A rate of 1 to 2 pounds of 2, 4-D per acre is needed to stop top growth and prevent seed production. Only slight stand reductions can be obtained from repeated foliage applications.

Soil sterilants should be used to eliminate small patches of Russian knapweed. Use sodium chlorate at 4 to 6 lbs./sq. rd. (640 to 960 lbs./A.), boron compounds at 7 to 10 lbs./sq. rd. of boron trioxide (1120 to 1280 lbs./A), or boron chlorate mixtures at 6 to 8 lbs./sq. rd. of active ingredient (960 to 1280 lbs./A.). CMU can be used on non-crop land when there is abundant soil moisture at 60 lbs./A. A fall application of 2, 4-D amine at 40-60 lbs./A. has also given good control of this weed. Spot treatment should be made the year following application of soil sterilants to kill remaining plants. Seedlings can be controlled with 2, 4-D foliage sprays, by cultivation or by seeding to a close growing grass crop and using supplemental 2, 4-D treatments.

Hoary Cresses (Cardaria spp.)

2, 4-D at 1/2 to 1 lbs./A. will control the top growth of hoary cress in growing crops when applied at the bud

stage. Retreatment of fall rosettes with 2, 4-D at 1-2 lbs./A. will give substantial stand reductions. Such a combination of treatments should give almost complete elimination after 2-3 seasons.

Soil sterilants can be used to eliminate small patches of Hoary Cresses. Sodium chlorate at 4 to 6 lbs./sq. rd. (640 to 960 lbs./A.) or boron chlorate mixtures at 6 to 8 pounds of active ingredient per sq. rd. (960 to 1280 lbs./A.) give satisfactory kills. CMU may be used on non-crop land when there is abundant soil moisture at the rate of 40 lbs./A. A fall or early spring application of 2, 4-D at 10 lbs./A. may also be used. Spot treatments following applications of soil sterilants should be used to kill remaining plants. Seedlings may be controlled with 2, 4-D foliage sprays, by cultivation or by seeding to a close growing grass crop and using supplemental 2, 4-D treatments.

Bur ragweed (Franseria tomentosa and Franseria discolor)

Bur ragweed may be effectively controlled by an application of 2, 4-D ester at the rate of 2 pounds per acre in the pre-bud stage in June.

Sodium chlorate at 4 to 6 pounds per square rod (640 to 960 pounds per acre), soluble boron compounds at 6 to 8 pounds per square rod of boron trioxide (960 to 1280 pounds per acre), the boron-chlorate mixtures at 6 to 8 pounds per square rod of active ingredients (960 to 1280 pounds per acre) or granular boron compounds at 8 to 10 pounds per square rod of boron trioxide (1280 to 1600 pounds per acre) can be used to eliminate small patches. A spot treatment the year following application of soil sterilants should be made to kill remaining plants.

Johnsongrass (Sorghum halepense L.)

Cultural methods (discussed above) are usually more economical for controlling extensive infestations of Johnsongrass than chemical methods. Chemicals are recommended for non-cultivated land and for spot treatment in fields. Recommendations are sodium chlorate, 3 to 5 lb. per sq. rod (480 to 800 lb. per acre); TCA, 3/8 to 5/8 lb. per sq. rod (60 to 100 lb. per acre); on non-crop land only CMU at 1/4 to 1/2 lb. per sq. rod (40 to 80 lb. per acre); a boron-chlorate mixture containing at least 20% sodium chlorate, 6 to 9 lb. per sq. rod (960 to 1440 lb. per acre); or Dalapon, 5/32 to 5/16 lb. per sq. rod (25 to 50 lb. per acre).

Toadflax (Linaria vulgaris Hill)

Soil sterilants can be used economically to eradicate small and scattered patches. CMU compounds at 40 to 60 lbs./A., sodium chlorate at 960 lbs./A., polybor chlorate at 1760 lbs./A. and Concentrated Borascu at 960 lbs./A. will give satisfactory control. While residual effect tends to be longer with CMU, each of the treatments given above would prevent successful crop production for a period of three or more years. Retreatment at lighter rates may be necessary to eliminate stray or surviving plants. Summer and fall application of sodium chlorate have been more effective than those made in the spring.

2, 4-D ester at 2 lbs./A. can be used to materially reduce the number of tillage operations required where intensive cultivation of fallow is being used to control field infestations. 2, 4-D at not less than 2 lbs./A. used in a program of intensive fallow and seeding down of large infestations to a competitive grass has been effective in reducing the stand and vigor of this weed.

Other Perennial Herbaceous Weeds

Poverty weed (Iva axillaris) can be controlled but not eradicated by spraying with 2, 4-D ester at a dosage of 2 lbs./A. in the bud stage of growth. CMU at 20 lbs./A. has given almost complete eradication.

Orange Hawkweed (Hieracium aurantiacum), Wild garlic (Allium vineale) and Tansy (Tanacetum vulgare) can be readily controlled by spraying with 2, 4-D ester at 2 to 3 lbs./A. in the bud to flowering stages and repeating the treatment in September.

Buttercup (Ranunculus acris) can be readily controlled by spraying with 2 lbs./A. of MCP amine in the spring when the weed is flowering.

CONTROL OF WOODY PLANTS

General Methods for Applying Chemicals in the Control of Woody Plants

For each method the concentration of chemical may vary considerably depending on whether eradication or complete control is desired, and on the economic considerations involved. The term AHG (number of pounds of acid per hundred gallons of diluent) is commonly used to express concentration. Rate of application (volume per acre) is not specified because it will vary with the abundance of the vegetation. It is assumed in all treatments except the aerial applications that volumes adequate to thoroughly wet the treated portions are used. Timing of application and environmental factors will seriously affect results. Therefore qualified local authorities should be consulted where possible.

1. Foliage applications. These involve spraying the foliage in the active growing season. In most cases such sprays are most effective when applied after the leaves have attained full size in the spring and before a reduction in activity takes place in late summer. Esters of 2, 4-D; 2, 4, 5-T; 2, 4, 5-TP[1/] or brush-killer mixtures of these two chemicals are used in these applications. Water is the most commonly used diluent, but oil-water emulsions and oil alone as a diluent may be desirable in some situations. Low volatile ester formulations should be used when there is danger of fumes reaching sensitive vegetation. Where selectivity is not required ammonium sulfamate is also recommended.

1/ The Dow Chemical Company has proposed Silvex as the common name for 2(2, 4, 5-trichlorophenoxy) propionic acid.

2. Basal - bark applications. Ester formulations of 2, 4-D; 2, 4, 5-T and brush-killer mixtures are effective on many species when applied to the base and ground line portions of trees and brush six inches in diameter or less. Such applications may be made either in the dormant or in the growing seasons. The relative effectiveness varies with different regions and species. The chemicals should be diluted in oil. It is important to liberally spray the entire base and ground line area.

3. Stump applications. Where the presence of dead standing trees is objectionable, the trees may be cut and the fresh stumps sprayed to a point of runoff.

Chemicals recommended include 2, 4, 5-T and 2, 4-D esters in oil or ammate applied as crystals or in a concentrated water solution.

4. Cut surface applications. Ammonium sulfamate and 2, 4, 5-T esters are recommended for application in "frills" or "girdles" cut to encircle basal portions of trees too large or thick barked to effectively kill by basal-bark treatments. For some species like cottonwood and willow 2, 4-D esters are also suitable. These treatments applied to standing trees are usually more effective in preventing resprouting than are cut stump applications. The ammate is applied as crystals or in a concentrated water solution and the 2, 4-D and 2, 4, 5-T in oil (dormant season) or water (growing season).

5. Aerial applications. Considerable variation in the effectiveness of aerial applications may be expected depending on the species treated and on conditions associated with the treatment. Several species have been effectively controlled using 1-3 pounds (acid equivalent) per acre of 2, 4-D; 2, 4, 5-T or brush killer mixtures applied in 2-5 gallons of oil or oil in water emulsions. The higher volumes give better coverage and more uniform results. Such applications should be made in the season of active growth for best results. These treatments are particularly useful where control rather than eradication is desired and on areas difficult of access by ground equipment. Repeat sprays may be required to give the required degree and duration of control.

Rangeland and Pastures

The growth regulator herbicides (low volatile esters preferred) and ammonium sulfamate will control many of the brush and tree species on land suitable for range and pasture development. However, their use should be accompanied by a management program which will favor prompt recovery of the desirable grasses and native legumes and thus reduce sprout regrowth.

The methods commonly used to apply the herbicides are foliage sprays and basal bark and cut surface treatments. The best time to apply foliage sprays on most woody plants is at full leaf and during the three to four-week period thereafter, providing soil moisture conditions are sufficient for active growth prior to time of spraying. The best period for spraying sand sage is during May or early June, when the plants have 6 to 8 inches of new growth and are rapidly developing. Basal bark and cut surface applications may be most advantageously made between December 15 and March 15. The rates of application given for 2, 4-D, 2, 4, 5-T, and 2, 4, 5-TP refer to acid equivalent.

Foliage Sprays (ground equipment) - Woody plants sensitive to either 2, 4-D, 2, 4, 5-T, or 2, 4, 5-TP ester may be controlled with a solution consisting of at least 3 pounds of the chemical in 100 gallons of water.

Ammonium sulfamate in a concentration of at least 3/4 pound in 1 gallon of water with the addition of a spreader-sticker is effective on mixed brush.

Foliage Sprays (aerial equipment) - The post oak, blackjack, and other associated brush and small trees may be successfully controlled with annual applications of herbicides for two to three consecutive years. If the 2, 4, 5-T or 2, 4, 5-TP is used, the initial application should be made at the rate of 2 pounds, followed by re-treatments of 1 to 2 pounds, emulsified in 1 gallon of diesel oil and 4 gallons of water, or 5 gallons of oil per acre. If a mixture of 2, 4-D and 2, 4, 5-T is used, the first application should be with 3 pounds and the following treatments with 2 pounds in the same quantity of spray solution as used for the 2, 4, 5-T or 2, 4, 5-TP per acre.

Studies on the control of shinnery oak indicate that effective results may be obtained with 2, 4-D ester at 1 pound in 3 to 5 gallons of diesel oil or in an amulsion of 1 gallon of diesel oil and 2 to 4 gallons of water per acre. This application must be made for two to three consecutive years to obtain effective control.

Mesquite has usually been successfully controlled with 1/2 pound per acre of the low volatile ester of 2, 4, 5-T or 2, 4, 5-TP in a single application. An effective spray solution for this species consists of 1 gallon of diesel oil with 3 gallons of water.

Sand sage is controlled with 1 pound of 2, 4-D ester in 3 gallons of an oil in water emulsion or the same quantity of diesel oil per acre.

Buckbrush may generally be controlled by repeated applications of 1 to 2 pounds of 2, 4-D ester per acre. The herbicide may be applied in 3 gallons of an oil in water emulsion or the same quantity of diesel oil per acre. This plant may also be effectively treated with ground equipment, using 1 to 2 pounds of the chemical in 100 gallons of water as a wetting spray. The effectiveness of control of this plant will vary with the difference in species, variety, and location.

Oil in water emulsions, such as 1:4, give larger droplet size than commonly used oils and thus reduce drift hazard.

Basal Bark Treatment - Basal bark and ground line treatments are good control measures on trees less than 6 inches in diameter. Concentrations ranging from 8 to 16 pounds of the low volatile 2, 4, 5-T ester in 100 gallons of diesel fuel are recommended for most species. However, cottonwood and willow may be controlled with the same quantity of 2, 4-D ester.

Cut Surface Treatment - Generally, 16 pounds of 2, 4, 5-T ester in 100 gallons of diesel fuel make an effective spray to be applied in frills or cups on larger trees and those having thick bark. The same solution, when applied thoroughly on freshly cut stumps, prevents sprouting. Regrowth on stumps may also be prevented by application of ammonium sulfamate in the crystal form or in a concentrated water solution (4 to 6 pounds per gallon).

Roadsides, Utility Lines, and Other Rights-of-way

Effective chemicals for the control of woody plants on rights-of-way are 2, 4-D and 2, 4, 5-T alone and in combination, and ammonium sulfamate. Mixtures of 2, 4-D and 2, 4, 5-T are useful when mixed stands of woody plants are to be controlled.

Foliage Sprays. Woody plants sensitive to 2, 4-D and 2, 4, 5-T should be treated using a wetting foliage spray containing at least 3 pounds of 2, 4-D and 2, 4, 5-T per hundred gallons of water. Brush killers containing 2, 4-D and 2, 4, 5-T are suggested where mixed species are encountered. Low volatile esters may be advantageous, especially in areas where volatility may be a problem. Ammonium sulfamate at a concentration of at least 3/4 pound per gallon of water is effective as a foliage spray on mixed brush. The addition of a spreader-

sticker to ammonium sulfamate is advisable. Aerial spraying on utility rights-of-way and roadsides is still in the development stage.

Basal Sprays (dormant and active growth period). Basal sprays with 2, 4-D and 2, 4, 5-T properly applied are usually more effective on the more resistant species than are foliage sprays. Smaller trees, usually under 6 inches in diameter are most responsive to this method. Applications of 2, 4, 5-T or mixtures of 2, 4-D and 2, 4, 5-T at rates of 8 and 16 pounds per hundred gallons of oil have proved effective. It is most important to spray the entire basal area of all stems to the point of run-off. Thorough coverage and high volume of spray with this method is most important.

Stump Treatment. In areas recently cut, as in the case of new rights-of-way or where dead standing trees are objectionable as along highways, the cut plants may be effectively treated by using 2, 4, 5-T or mixtures of 2, 4-D and 2, 4, 5-T at rates of 8 and 16 pounds of acid equivalent per hundred gallons of oil. The material should be applied to the stump so as to completely wet the top and sides of the stump to ground level. All exposed roots should be sprayed. Sufficient volume is most important with this method. Ammonium sulfamate applied as crystals or as a concentrated water solution (4 to 6 pounds per gallon) is effective in preventing sprouting of stumps.

CONTROL OF WOODY PLANTS IN FORESTS, FOREST PLANTATIONS, AND FARM WOODLANDS

Chemicals may be useful in several ways in connection with controlling undesirable woody plants on forest, plantation, and woodland areas. In many of these applications a goal of temporary control rather than permanent eradication of the woody weeds may be adequate in obtaining the desired objectives. Foliage sprays, cut surface and basal applications are all useful under certain conditions.

For purposes of freeing coniferous regeneration from brush competition, foliage sprays containing two pounds of ester formulations of 2, 4-D or 2, 4, 5-T, per hundred gallons of spray are recommended. Where the brush consists of hazel, willows or alder, 2, 4-D is adequate. For the control of blackberries, raspberries, cherry, thornapple, ash, osage-orange, basswood and maple 2, 4, 5-T is more effective. For mixed brush populations, mixtures of 2, 4-D and 2, 4, 5-T are recommended. Foliage applications should be made after the leaves have attained full size and before their activity has been reduced in late summer. Such applications, properly made, will usually be effective in reducing competition to coniferous seedlings for 3-5 years. Where control for a longer period is necessary, repeat sprayings are recommended.

Where brush control is necessary preliminary to the planting of trees for forest plantations, foliage treatments using 2, 4-D, 2, 4, 5-T, or ammonium sulfamate can be used. If natural regeneration of conifers are present on the area, 2, 4-D or 2, 4, 5-T should be used exclusively to avoid killing the conifers.

Chemical treatment can be useful in releasing established plantations from overhead competition and in eliminating poorly formed individuals or inferior species from sapling or pole-sized forest stands. For this purpose cut surface treatments in frills or cups as well as basal applications are recommended. Esters of 2, 4, 5-T in oil solutions at concentrations of 8 to 16 pounds of acid per hundred gallons of oil are recommended for both cut surface and basal types of application. Ammonium sulfamate as a dry salt or as a concentrated water solution (4 to 6 pounds per gallon of water) can be effectively applied to cut surfaces of stumps, frills or cups to prevent resprouting of most species of woody plants. The addition of a sticker or spreader to such water solutions may be necessary.

In some situations aerial sprays have been found to be a cheap and relatively effective method for releasing conifers from an undesirable overstory or competition from brush. Rates of from 1 to 3 pounds per acre of 2, 4-D or 2, 4, 5-T acids or their mixtures in 2 to 5 gallons of oil or oil-water emulsions have been found to be successful in some cases in controlling aspen, alder, oak (bur, northern red and northern pin oaks) and paper birch.

In general, spraying in desirable stands of conifers should be confined to the last half of the growing season to avoid damaging the succulent new growth.

Alternate Hosts

Barberry (Berberis spp.), the alternate hosts of stem rusts of wheat, oats, barley and rye. European barberry (B. vulgaris) can be killed by common salt liberally applied around the base of the plant, but ammonium sulfamate applied to the surface of cane stubs cut at the ground line or basal sprays of MCP ester or a combination of 2, 4-D and 2, 4, 5-T esters (plus PCP) at 14 pounds ahg oil solution also are effective and easier to apply. Colorado barberry (B. fendleri) may be killed also with 2, 4-D ester in foliage and dormant stages with 1.6 ahg water emulsien and 10-14 pounds ahg oil solution, respectively, as well as with sodium chlorate ("Atlacide"). Allegheny barberry is killed in both the foliage and dormant stages by 2, 4, 5-T ester at 12-14 pounds ahg oil solution or a combination of 2, 4-D and 2, 4, 5-T esters plus PCP.

Currants and gooseberries (Ribes spp.), the alternate hosts of white pine blister rust. Basal treatments with 2, 4, 5-T ester or a combination of 2, 4-D and 2, 4, 5-T esters at 8 to 14 pounds ahg oil solution kill most upland ribes, namely: R. cynosbati, R. missouriense, R. hirtellum, and R. americanum. The latter species also can be killed in both the foliage and dormant stages with 2, 4-D ester at 0.75 to 1.6 pounds ahg water emulsion and 8 to 14 pounds ahg oil solution, respectively. Prostrate swamp species are usually more difficult to eradicate. Overall sprays using oil solutions of 2, 4, 5-T are effective. In Ribes control, careful application is essential.

Buckthorn (Rhamnus spp.), the alternate host of crown rust of oats. Eradication of buckthorn by mechanical uprooting, ammonium sulfamate applied to cut stems, or a mixture of 2, 4-D and 2, 4, 5-T in oil applied as a basal spray has been recommended.

Red Cedar (Juniperus virginiana), alternate host of apple, pear, and quince rusts. These trees may be killed with common salt (sodium chloride), sodium chlorate, and possibly other soil sterilants applied at the ground line. A foliage wetting spray of 3/4 pounds ammonium sulfamate per gallon of water is also effective.

Shrubs Poisonous to Touch

Poison Ivy (Toxicodendron or Rhus spp.). A thorough foliage spray of 2, 4, 5-T ester or a combination of 2, 4-D and 2, 4, 5-T esters at 2 pounds ahg water emulsion is recommended. A dormant spray of 2, 4, 5-T at 12 pounds ahg in oil may be used. Ammonium sulfamate, sodium chlorate, or borax formulations also have proved effective.

Poison Sumac (Rhus vernix). Due to the height of this shrub and danger of skin poisoning, treatment with either a growth regulator, ammonium sulfamate or a soil sterilant type of herbicide in the dormant rather than the foliage stage is recommended.

AERIAL SPRAYING

Aerial applications of herbicides are economically advantageous and often more effective than other methods under many conditions. Factors to be considered in determing these advantages are: size of area to be sprayed, time available for treating a given area, inaccessibility of the area to other equipment, suitable weather conditions, proximity of other crops which may be damaged by drift, comparative results and costs of aerial applications as against results and costs of other methods.

The most advantageous use of aerial spraying at present is for brush control (mesquite, sagebrush, oak brush and others), for weed control in small grains, pastures, ranges and other large areas and for preharvest defoliation and desiccation.

Even distribution is essential in all herbicide applications with a minimum of drift. Therefore, the swath width should be 40-45 feet or less and the altitude should be as close to the foliage as safety of the pilot and equipment will permit (boom 4 to 5 feet above foliage on flat terrain and even growth; more clearance as necessary on uneven growth and terrain). The plane should be operated crosswind in order to maintain constant ground speed; but where it is necessary to fly parallel to the wind, flights can be made both up-wind and down-wind providing the pilot can control his airspeed so that ground speed will be constant; otherwise they should be made up-wind only.

If aerial spraying of 2, 4-D or Brushkillers is recommended in areas where susceptible crops are grown, only low volatile materials should be employed.

Drift injury to near-by crops represents one of the greatest problems of aerial applications. All aerial spraying equipment should be designed and operated in a manner which will reduce the drift hazard.

Spraying should be done when the wind velocity is constant in direction and as low as possible. The following wind velocities are suggested as possible maximums for these representative conditions but the operator's judgment and local conditions will be the final determining factor:

2, 4-D in mixed farming area at 1 - 2 gal/acre	wind velocity	5 mph
2, 4-D in mixed farming area at 5 gal/acre	wind velocity	7 mph
2, 4-D in range country at 1 - 2 gal/acre	wind velocity	7 - 10 mph
Chemical desiccants anywhere at 5 - 8 gal/acre	wind velocity	8 - 10 mph

Large droplets minimize probability of drift, therefore, large orifice nozzles should be used at low spray pressure. When it is necessary to increase the rate of spray application, it generally should be accomplished by increasing the number of nozzles, orifice size or other means rather than by increasing the spray pressure. Nozzles should be directed downward and to the rear. Each nozzle should be equipped with a positive shutoff. Light oil diluents break up in finer droplets than water because of lower surface tension, therefore, water or emulsions should be considered where drift presents a hazard.

Many chemicals settle out of solution or emulsion when allowed to stand so each plane load should be mixed just prior to take-off or the spray solution in an auxiliary tank should be thoroughly agitated before each plane load is removed from it. It is desirable that each plane have positive agitation equipment in the tank.

It is recommended that all owner-operators and pilots be familiar with the character of the chemical being used. Owner-operators should exercise close control over the operation of their planes. In the interests of safe operation, each plane should be equipped with all of the safety equipment (helmets, safety harness, masks, dump valves, wire cutters on the landing gear, etc.) which is necessary. There is no substitute for good maintenance of the airplane and equipment. The pilot should make a preliminary survey to familiarize himself with potential hazards and obstructions in and around the area over which he is to fly.

The following are considered desirable features of aerial spray equipment:

Tank: The spray tank should be of light weight material. Fiberglass reinforced plastics, aluminum, and stainless steel are preferred for corrosion resistance. It should have a large filler opening to allow for easy cleaning and filling and have baffles to prevent surging if the tank is large in fore and aft dimensions.

Pump: Positive displacement pumps of the gear type produce high pressures and require a relief valve, while centrifugal pumps with lower maximum pressures do not need a relief valve and are capable of handling suspensions. Pumps driven by external fans need a brake assembly and those engine-driven require a clutch.

Booms: The boom should be large enough to prevent a significant pressure drop at the end nozzles and the ends should be fitted with caps for cleaning. Round booms produce more drag than streamlined ones but they are easier to clean. The boom should have fewer nozzles in the 3 to 4-foot space left of center and more nozzles to the right of center to overcome the spray displacement caused by the propeller slip stream. To minimize the effect of the wing tip vortex, no nozzle should be placed within 3 feet of the wing tip. On high wing monoplanes, lowering the outer ends of the booms so there is approximately 3 feet between the boom and lower wing surfaces aids materially in reducing wing tip swirl.

WEED CONTROL IN FIELD CROPS

Spring Sown Grain

Wheat and barley are more tolerant to 2, 4-D foliage applications than are oats. Wheat is more tolerant than barley. All three crops are sensitive as seedlings from emergence to the 2-leaf stage. Wheat and barley are relatively tolerant from the 5-leaf stage up until the early boot stage. During this period 1/4 to 1/3 pound 2, 4-D as an ester or 1/2 to 2/3 pound 2, 4-D as the amine salt may be used. At these rates most annual broad-leaved weeds will be controlled without injury to the crops. Wild buckwheat and annual smartweed are more resistant and may only be stunted.

Some injury to oats should be expected from 2, 4-D sprays used at any time from seedling to early boot stages of growth. The jointing stage is apparently a time of greatest sensitivity in oats. Applications made from early boot on through heading are generally safe. Oats are more tolerant of MCP than of 2, 4-D permitting the use of rates up to 1/2 pound or more. Certain weed species are not controlled by MCP. Consult local authorities for information on susceptibility of weeds in your area.

For resistant broad-leaved weeds or grasses, particularly wild oats, careful attention should be given to proper pre-seeding cultivations and crop rotations. Delaying seeding for three to four weeks along with proper cultivations will reduce the wild oat population.

Fall Sown Wheat

Winter wheat may be treated with 2, 4-D in dosages sufficient to control most annual broad-leaved weeds with little injury to the crop if applied in the spring from the fully tillered through the early jointing stage, but before the boot stage of growth. From 1/4 to 1/2 lb. of 2, 4-D acid equivalent to the acre as an ester or up to 3/4 lb. as an amine are suggested dosages. Similar applications made in the fall usually result in damage to the crop and are not recommended. Pre-harvest treatment applied when the wheat is in the milk to hard dough stage should be looked upon as an emergency measure to be used only when weeds threaten to interfere seriously with harvesting. A dosage of 1 pound 2, 4-D to the acre is usually required at this stage and may result in damage to the crop. Weed control at this stage is often not satisfactory. Contact herbicides can be used to give rapid drying of large weeds just prior to harvest. Weeds and weedy grasses resistant to 2, 4-D may be controlled best by proper pre-seeding cultivations and crop rotations.

Corn

Weed control in corn is based primarily on cultural practices, including seed bed preparation, establishment of an adequate stand of corn, and timely and effective cultivations. The use of shallow cultivation implements such as the rotary hoe, is highly recommended for the early cultivation operations. Spraying with 2, 4-D can be used to reduce the number of cultivations needed and to control some weeds in the row or hill. It should not be expected to replace cultivation because weeds not controlled by 2, 4-D will be given an opportunity to develop. Cultivation is needed regardless of weeds on some soil types.

Post-emergence. Spraying should be timed to give complete and early control of the weeds. Rates of 1/4 to 1/2 pound per acre have proven satisfactory; the esters must be used at lower rates than the amines. Lower rates are safer and should be used whenever the danger of corn injury is great, or when very susceptible weeds are to be controlled. Up to 1 pound may be used for resistant weeds with probably injury to the corn. If spraying must be done at any time when the corn is large enough to put the spray under the top leaves by means of drop nozzles, this should be done unless the weeds are taller than the corn. The spray must strike the tops of the weeds to be most effective. When two nozzles are directed on each row a spray solution equivalent to no more than 0.25 lbs/A should be used. Some injury to corn may result from 2, 4-D spray treatments made during the period from emergence to tasselling. Brittleness and bending or breakage of stalks is the most serious type of injury, and it may result in severe stand losses when followed by a storm or cultivation. Several factors influence the degree of injury to corn resulting from 2, 4-D treatments. Corn developing under optimum conditions for growth is more susceptible to 2, 4-D injury than corn developing under less favorable growth conditions. At the rates of application commonly used for weed control in corn during the period of emergence to tasselling, it is probably that the morphological stage of growth at which 2, 4-D treatment is made is less important than the effects of environmental factors on the response of corn to the 2, 4-D except the period extending from two weeks before silking until the silks are dry. Severe reduction in seed set may result from 2, 4-D treatments made during this period, regardless of growing conditions. Hybrids and varieties vary in their susceptibility to 2, 4-D, but differences are not important at rates below 1/2 pound per acre. Inbred lines vary more widely and single cross seed fields should not be sprayed except in an emergency, or on inbreds of proven tolerance, and then at minimum rates.

In areas where annual grasses present a serious weed control problem, the use of selective sprays of the DN type herbicides have shown promise. Some corn injury in the form of leaf burn often results, but yield reductions are generally not serious. An application of 2-4 pounds per acre in 20-40 gallons of water per acre is suggested. Treatment should be made while corn is in the coleoptile stage, to minimize injury to corn. These low rates of application give no residual effect and can only be expected to kill the seedling grasses, present at the time of spraying.

Pre-emergence. In most of the area pre-emergence with 2, 4-D will control annual grasses and some tolerant broad-leaved weeds such as purslane, which are not controlled well by post-emergence sprays. On loam soils and those of finer texture, pre-emergence use of 2, 4-D is satisfactory if applied before emergence at rates of 1 to 2 pounds per acre. The ester formulations are less hazardous to the corn than amine salt formulations. Dry weather after pre-emergence treatments may make then ineffective and excessive rain creats a hazard to the corn. One pound per acre may not control all weeds but is often more economical, considering cost of materials. The effectiveness of pre-emergence herbicide treatments is greatly increased when the remaining stunted weeds in the hill or row are covered by follow-up cultivations. Soils high in organic matter will require larger dosages than soils low in organic matter. Pre-emergence applications are not recommended on sandy soils. An application of 2, 4-D at pre-emergence rates, on the soil and bases of the corn stalks only, just after the last

cultivation may prevent the emergence of weeds which otherwise might interfere with harvest. Bending of the stalks at the lowest nodes may follow this treatment.

Flax

Cultural Practices - Weeds are generally more of a problem in flax than in small grain, therefore, growers should sow flax on relatively clean land. Early after-harvest tillage of small grain stubble to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall is a recommended method of preparing land for flax the following year except where after-harvest tillage results in serious wind erosion. Preventing weed seed production in corn, soybeans, and other cultivated crops, followed by surface tillage in preparing the seedbed for flax is desirable weed control practice. Delayed sowing of flax to permit spring tillage for wild oat control has been successful in some areas, although the delay is sometimes detrimental to flax. For delayed sowing, early-maturing varieties such as Sheyenne or Marine are generally recommended.

Herbicides - Flax should be sprayed with MCP or 2,4-D as soon as there is sufficient emergence of susceptible weeds to make spraying practical. Spraying may reduce yields of seed and straw unless weed competition is reduced sufficiently to offset injury from spraying. MCP is less likely than 2,4-D to injure flax and is therefore the preferred material. Use 2 to 3 oz/A or MCP or 2,4-D in amine formulations for suseptible weeds like wild mustard. Use 4 oz for lambsquarters, red-root pigweed, stinkweed, cocklebur, marsh elder, and ragweed. For moderately resistant weeds, spot spraying at heavier rates may be necessary. Use MCP at 5 to 6 oz/A to prevent seed production by Canada thistle and perennial sow thistle. Use 2,4-D ester at 3 oz or MCP ester at 4 to 5 oz/A to control Russian pigweed and Russian thistle.

Do not spray flax with MCP or 2,4-D during the period between full bloom and the stage when 90% of the bolls have formed, as yields have been greatly reduced by spraying between those stages. Flaxseed germination may be reduced by spraying between full bloom and the stage when seeds are colored, so flax grown for seed should not be sprayed during this period.

TCA at 5 lb/A will kill green foxtail, yellow foxtail, giant foxtail, and barnyard grass in young flax. The flax should be at least 2 in. tall and the weeds less than 2 in. for best results. TCA can be applied in mixture with MCP or 2,4-D to kill susceptible grass weeds and susceptible non-grass weeds with one application, but this mixture should not be applied after early bud stage.

When flax is used as a companion crop to establish alfalfa, red clover, alsike clover, Ladino clover, timothy, meadow fescue, bromegrass, or crested wheatgrass, use MCP or 2,4-D as directed for flax except that alfalfa or clover seedlings should be at least 2 in. tall. Sweet clover seedlings will probably be killed if the flax is sprayed with MCP or 2,4-D. TCA can be used on flax sown with alfalfa or sweet clover, but TCA will probably kill red clover, alsike clover, timothy, meadow fescue, bromegrass, or crested wheatgrass.

Sorghum

The use of 2,4-D for weed control in sorghum is recommended only when weeds cannot be controlled by cultivation. Sorghum is more tolerant to 2,4-D when 4 to 8 inches high; severe injury may occur from treatments applied to sorghum less than 3 inches high, or from 18 inches in height through the blooming stage. The most common injury is brace root malformation that may or may may not lower yields. Severe injury is characterized by late maturity, dwarfing of plants, sterility and possible death of young plants. The forage sorghum appears to be more resistant to 2,4-D than the grain types. Some grain sorghum varieties are more susceptible to 2,4-D than others. Rates of 1/4 to 1/2 lb/A of 2,4-D are suggested for use on sorghum. Minimum dosage should be used during periods when the crop is most susceptible to 2,4-D. If more than 1/2 lb/A is necessary for weed control some damage may occur.

Soybeans and Peas

Soybeans. There are several cultural practices that are useful in controlling weeds in soybeans. Delayed planting combined with early seedbed preparation and frequent cultivation to kill weeds until the planting data are successful in reducing the weed hazard. Growing soybeans in cultivated rows will make weed control easier and more certain than in solid seeded beans.

Chemical weed control in soybeans has not been fully dependable. There are no post-emergence sprays recommended for soybeans but pre-emergence treatments offer possibilities. DNBP at 4 to 8 pounds per acre has given the most consistent results as a pre-emergence herbicide for soybeans. CIPC at 4 to 8 lb. has also given good results as a pre-emergence treatment. The lighter rates of each chemical are recommended for the lighter type soils. Chemical applications just before bean emergence has given better weed control with less crop damage than applications at planting time. As with all pre-emergence herbicides, the results will vary with weather conditions.

Peas. Weed control in canning peas is usually accomplished by thorough seedbed preparation prior to planting. Annual broad-leaved weeds may be controlled when in the 2- to 4-leaf stage by applying from 3/4 to 1 pound per acre of DNBP as an amine salt in approximately 40 gallons of water.

Broad-leaved annual weeds may also be controlled by applying from 2 to 6 ounces per acre of MCP amine or sodium salt to peas between 3 to 7 inches in height. Canada thistle can be controlled by application of from 4 to 6 ounces of MCP per acre.

Sugar Beets

Recommended crop rotations and methods of cultivation suited to conditions within the particular sugar beet growing area are the principal means of weed control.

Where annual grasses (except for wild oats, Avena fatua) are known to be a problem the application of 5 to 7 pounds per acre of TCA just before the emergence of the beets is recommended.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait ten days. TCA at the above rates may then be used to control annual grasses. Some beets will be stunted. This should be considered an emergency treatment only.

Selective control of certain broad-leaved weeds may be obtained by the application of sodium chloride (NaCl).

From 200 to 300 pounds per acre in 100 to 200 gallons of water, applied when the beets have 2 to 4 true leaves is required. This treatment is not effective on lamb's quarters and purslane. Recommendations for the particular beet growing area should be followed for all above methods.

On moist soil or on areas which can be irrigated, pre-planting applications of from 3 to 5 pounds of IPC per acre, disced into the soil before planting, may be used to control wild oats.

Forage Legumes

Seedling legumes grow slowly and usually are poor competitors with weeds. To prevent the production of weed seeds in preceding crops the use of intertilled crops and after-harvest tillage are suggested. Mowing weeds in legume seeding, (except sweetclover) has merit if done low enough and late enough to kill most of the annual broad-leaved weeds.

Avoid the use of herbicides on seedling legumes unless the crop is seriously threatened by weeds. When weeds are a serious problem, seedling stands of ladino clover, alsike clover, red clover, alfalfa, and lespedeza may be sprayed with the sodium or amine salts of 2, 4-D and MCP, at rates of 1/4 lb. or less per acre. Sweetclover usually will be injured by either 2, 4-D or MCP applications. In the more humid areas of the region a complete canopy formed by the companion crop and/or weeds will reduce the injury to the legumes.

The dinitro sprays are effective on very small annual weeds in seedling legumes. The amine salt of DNBP at rates of 1 to 1/2 lbs. in 25 to 40 gal. of water per acre is suggested. With high temperatures and/or humid conditions, use lower amounts of DNBP.

TCA at 5 to 7 pounds per acre may be used to control many annual grasses in seedling stands of alfalfa, sweetclover, and birdsfoot trefoil. Apply TCA pre-emergence to the weeds or while the weeds are very small. Alsike, red clover, and lespedeza are killed by TCA treatments. Also, it cannot be used when grass crops such as wheat, oats, or barley is used as a companion crop.

In established legumes, the use of 2, 4-D or MCP is often hazardous. These herbicides may be applied in the early, dormant stage of the legume. Serious yield losses, and often stand losses, may result from spraying after growth has been initiated. The dinitro products may be used on established legume stands as listed above for seedling legumes but at 1 to 3 lbs./acre. Established stands of alfalfa, sweetclover, and birdsfoot trefoil may be treated with TCA at 5 to 7 pounds per acre, for control of many annual grasses, without permanent injury to the legumes. Ladino clover, alsike, red clover, and lespedeza should not be treated with TCA.

CONTROL OF HERBACEOUS WEEDS IN PASTURES AND MEADOWS

Good management and controlled grazing are of first importance in any attempt at weed control in pasture land.

In very weedy pastures where good perennial grasses are thin, reseeding may be the most important improvement practice. To be successful, a good, firm seedbed should be prepared for any reseeding and fertilizer needs should be taken care of at time of seedbed preparation. Protect new seedlings from grazing until established and graze moderately thereafter. Plowing and seeding to adapted grass species where practicable, will usually eliminate many of the perennial pasture weed species. This practice supplemented by 2, 4-D treatment gave better control of all weedy species than either 2, 4-D or mowing treatments in one reported experiment.

Spraying with 2, 4-D, 2, 4, 5-T or a mixture of the two gives better control of more kinds of weeds by a single application than is obtained by a single mowing treatment. Spraying during active growing condition of the weeds is essential for good results. Repeated treatment for two or more years is usually necessary. Increased production of desirable forage and improvement in grass stands following treatment has been reported. In general, these chemicals may be used at rates necessary for weed or brush control without appreciable injury to the grasses. While these chemicals may eliminate some legume species, other native and introduced legume species have a relatively high tolerance to some of the growth regulators.

Seedlings of perennial grasses may be advantageously treated with 2, 4-D if the broad-leaved weeds are a problem and if the land is not heavily infested with seeds of the weedy annual grasses. Rates up to 3/4 pound per acre may be used after the grass seedlings have reached the 2- to 4-leaf stage of growth. Where weedy annual grasses are the major problem, clipping to prevent seed production may be used successfully.

Mowing has been a recommended practice for controlling many kinds of weeds if done at the right time for 2, 3, or 4 years. In general, mow herbaceous weeds in the early bud to blossom stage. One report on ironweed indicated that mowing at the best stage for 4 years gave 1/3 control whereas similar mowing at other stages gave very poor results.

Chemical Drying and Pre-Harvest Weed Control

The presence of weeds and green crop material in many crops at harvest time frequently complicate harvest operations and result in considerable loss of seed. If crops can be dried seed losses and harvesting costs may be considerably reduced. Since contact-type chemicals are used the volume of application is important. Oil or oil-water emulsions improve wetting when oil soluble chemicals are used. Wetting agents should be used with water soluble materials. Chemical drying is most practical when used on high value seed crops. Only a small number of experiments have been conducted on some crops in the North Central Conference area and in view of this the following suggestions are offered:

Alfalfa and Clovers. Treatments should be applied to alfalfa when most of the seed pods have turned brown. On crops such as sweet clover where shattering may be a serious problem applications should be made when approximately 50% of the pods are brown. DNBP at 1.25 to 1.87 lbs. and PCP at 4 to 6 lbs. applied in 5 to 10 gallons of diesel fuel per acre have given satisfactory results. In some regions endothal at 1 to 1 1/4 lbs. plus 4 to 6.25 lbs. ammonium sulphate in 20 gallons of water per acre has been equally effective or superior to DNBP and PCP.

Flax. DNBP at 1.25 to 1.87 lbs. applied in 5 to 10 gallons of diesel oil or 1.25 lbs. endothal plus 4 to 6.25 lbs. ammonium sulphate are recommended for pre-harvest drying in flax.

Soybeans. The same materials and rates recommended

for alfalfa and clovers are suggested. Treatment should be applied when most of the pods have turned brown, or some reduction in yield and quality may be expected.

CONTROL OF WEEDS IN HORTICULTURAL CROPS

By the wise use of chemicals, it is possible to reduce greatly the cost of weeding many horticultural crops and to save some crops when wet weather makes it impossible to cultivate. However, chemical weed control must not be considered as a substitute for all cultivation but rather should be used to supplement standard cultural practices. There are many herbicidal treatments in addition to those listed here that may be valuable in certain localities. Only those that are of regional interest have been included in these recommendations. For other possible treatments local authorities should be consulted.

All rates of application are based on over-all coverage. It is often more economical to treat only a narrow strip over the row, in which case the application should be reduced accordingly.

Vegetable Crops

Asparagus. The common practice in most areas is to disc asparagus beds in early spring to loosen the soil, destroy weeds and to remove the old ferns. After discing and before spears have emerged, 2, 4-D may be applied at the rate of 2 pounds or SES at 4 to 6 pounds per acre as a pre-emergence spray for the control of broad-leaved weeds. If annual grasses are a problem 5 to 8 pounds of TCA may be added to the 2, 4-D or SES spray. CMU at 1 to 2 pounds, DNBP at 6 to 8 pounds and N-1 naphthyl phthalamic acid at 4 to 8 pounds per acre have also been used successfully at this time for the control of both annual grasses and broad-leaved weeds. On muck soil higher rates of application are needed for all materials except TCA.

Following the post-harvest discing, the above herbicides may be used before any spears are showing, but present evidence indicates that it is wise to apply 2, 4-D, TCA and CMU only once during any season.

The use of Stoddard solvent at 80 to 100 gallons, DNBP at 1 pound or 2, 4-D at 1 pound per acre are recommended for contact pre-emergence treatment to control weeds in asparagus seedbeds.

Beans. In most areas residual pre-emergence sprays to control weeds in the row together with cultivation between the rows have proven quite successful. A smooth well-prepared seedbed is important where pre-emergence sprays are used.

Six to 9 pounds of DNBP or 15 to 25 pounds of sodium PCP per acre of actual sprayed area will control most annual weeds for a considerable period. The higher rates should be used where sprays are applied very soon after planting. When sprays are delayed until shortly before bean emergence, at which time many weeds may have emerged, the lower rates may be used with equal effectiveness. Where very serious infestations of annual grasses threaten, it may be necessary to apply in excess of the highest rate suggested above. Optimum concentrations of the above chemicals which may be used on various soil types without injury to the crop must be determined by preliminary field trials. Both of these herbicides may cause injury when temperatures are high.

CIPC at 4 to 8 pounds per acre has been used successfully where weeds such as smartweed that are difficult to control with the above materials make up a large part of the population. The higher rate is for heavy soils or those that are high in organic matter. The application should be made as soon as possible after planting. CIPC will control many annual grasses and broadleaved species but is not effective on lamb's quarters and ragweed.

Beets. For annual grasses, a residual pre-emergence spray of 8 to 10 pounds per acre of TCA has provided excellent control. For best results the land should be well prepared by the removal of as many lumps and clods as possible. There appears to be some advantage in the control of grasses and a few small broadleaved weeds if the spray is applied 3 to 4 days after planting.

If the weather makes it impossible to apply the spray before emergence of the crop, it is best to wait 10 days. Ten pounds of TCA may then be used to control grasses only. Some beets will be stunted. This should be considered an emergency treatment only.

Cabbage, Cauliflower and other Vegetables of the Genus Brassica. When any of these crops are direct-seeded a pre-emergence spray of 5 to 8 pounds per acre of TCA may be used to control annual grasses.

Carrots, Celery, Dill, Parsnips, and Parsley. Small annual weeds may be controlled on muck and upland soils with applications of Stoddard solvent at the rate of 80 to 100 gallons per acre if the entire area is sprayed. The quantity may be reduced substantially if only a narrow band over the row is treated. The sprays should be applied when most of the first crop of weeds has emerged but before any of them are more than two inches tall.

Maximum effectiveness may be obtained, and in some instances with lower rates, by applying the chemical at night when air movements are down and the relative humidity is high. Early evening applications before the dew has formed may prove most satisfactory in those areas where exceptionally heavy dews may cause excessive run-off of the chemical later at night.

Carrots and parsnips should not be sprayed after the tap root is more than one-fourth inch in diameter or after five or more leaves are present. Stoddard solvent may be applied to celery only in the seedbed.

Onions. For the control of weeds that have emerged before the onions, Stoddard solvent at 60 to 80 gallons per acre, or 3 to 5 per cent sulfuric acid at 100 gallons per acre can be used as pre-emergence sprays. CIPC has given good results when applied just before onion emergence at 4 to 6 pounds on heavy mineral soil and 8 pounds on muck where lamb's quarters and ragweed are not important. It is particularly effective on smartweeds (Polygonum spp.) and purslane (Portalaca oleracea), giving residual control for 2 to 4 weeks on these species. Pre-emergence sprays with combinations of CIPC and contact weed killers such as Stoddard solvent have controlled a wide variety of weed species.

For the control of weeds in onions in the "loop" stage post-emergence sprays of 2 to 3 per cent sulphuric acid at the rate of 100 gallons per acre, or potassium cyanate at 12 to 16 pounds in 50 to 100 gallons of water per acre is recommended. Purslane is controlled only

in the catyledon stage and lamb's quarters and grasses are usually not killed. CIPC at 8 pounds has also been used successfully at this stage on muck soil.

For the control of weeds in onions having three leaves or more basal applications of 3 to 4 per cent sulphuric acid at 100 gallons per acre, 16 to 20 pounds of potassium cyanate, or 8 pounds of CIPC in 50 to 100 gallons of water per acre is recommended. The CIPC treatment is particularly effective for the residual control of purslane (Portulaca oleracea). All such sprays should be applied so as to avoid hitting the tops of the onion plants.

Potatoes. While blind cultivation is generally preferred to control weeds before the emergence of potatoes, in wet weather chemical treatments may be valuable. DNBP at 5 to 10 pounds and sodium PCP at 15 to 30 pounds per acre have given good results when applied 2 to 6 days before emergence. The higher rates are used on muck soil. Where annual grasses are a problem TCA at 8 to 10 pounds per acre may be used as a pre-emergence spray either alone or in combination with one of the above herbicides.

Spinach. Several kinds of annual grasses and broadleaved weeds can be controlled in spinach with pre-emergence applications of CIPC. For early spring plantings 2 pounds of CIPC per acre is suggested on sandy soils, 4 pounds on heavier mineral soils and 8 pounds on muck. For fall plantings, 4 pounds is suggested on sandy soils and 6 pounds on heavier mineral soils.

Sweet corn. Pre-emergence treatments of 2, 4-D at 1 1/2 to 2 pounds per acre or 6 to 8 pounds of DNBP have given generally good results except on sandy soil. When 2, 4-D is used the low volatile ester formulations are preferred. On muck soil, the rates should be increased by 50%. When sprays of DNBP are delayed until shortly before sweet corn emergence, at which time many weeds have emerged, 4 to 6 pounds may be used with equal effectiveness. These pre-emergence treatments have the advantage over post-emergence applications of 2, 4-D, of controlling purslane and reducing the stand of annual grasses.

Post-emergence sprays of 2, 4-D at 1/4 to 1/2 pound per acre have controlled most broadleaved weeds without reducing the yield of sweet corn. The lower rate is for ester formulations. Stalk abnormalities and lodging occur to some extent but have not usually been serious. Spraying should be done when the weeds and corn are small. On larger sweet corn the use of drop nozzles will reduce the possibility of injury but thorough weed coverage is essential.

Direct-seeded tomatoes. Where a large number of weeds come up before the tomatoes, Stoddard solvent may be applied at 50 gallons per acre about 2 days before the tomatoes start to emerge. Where annual grasses make up most of the weed population, a pre-emergence treatment of TCA at 3 pounds per acre two days before emergence has given good results. A combination of 3 pounds of TCA with either 12 pounds of sodium isopropyl xanthate or 16 pounds of potassium cynate is especially effective where a mixture of grasses and broadleaved weeds occur.

Vine Crops. Weeds in cucumbers, muskmelons and watermelons have been controlled successfully with N-1 naphthyl phthalamic acid. It may be applied as a pre-emergence treatment immediately after planting these crops at from 2 to 3 pounds per acre on light sandy soils, 3 to 4 pounds on light-colored loams or 4 to 6 pounds on heavy or dark-colored soils. It can also be used as a post-emergence spray where these crops are grown from transplants. In this case the rate of application should not exceed 4 pounds per acre. N-1 naphthyl phthalamic acid should not be applied to extremely early plantings of vine crops when the soil is cold.

Certain varieties of pumpkins and squash are less tolerant to this herbicide than the other vine crops. They should be sprayed only in accordance with local recommendations.

Seedbeds and plantbeds. Weeds can be controlled in seedbeds and plantbeds with steam sterilization or fumigation with methyl bromide.

Waste places adjacent to vegetable fields. Weeds along drainage ditches and fence rows, around buildings, under irrigation lines, and other waste places can be effectively controlled with oils, DNBP, PCP and TCA.

Fruits

Brambles. Weeds within the plant row of brambles grown in a hedge row or linear system cannot be controlled by machine cultivation. A deep mulch of sawdust, shavings, ground corn cobs, or straw helps measurably in the control of these weeds but the cost may be prohibitive under certain conditions and, moreover, the mulch presents certain hazards. Weeds will grow through these materials in time.

Sodium 2, 4-dichlorophenoxyethyl sulfate (SES) is effective as an herbicide for use in raspberries. It can be used at the rate of 3 to 6 lbs. per acre at any season without injury to canes, foliage, new shoots or fruits. To be effective this chemical must be applied before weeds emerge from the soil. SES is effective against both broad-leaved weeds and grasses.

This crop is somewhat tolerant of 2, 4-D and DNBP (amine). Basal directed aprays of these chemicals, if carefully applied with low pressure equipment, will not damage the canes and will control many species of weeds. The first application should be made early in the spring before the weeds and new bramble shoots emerge. The second application should be delayed until the new bramble shoots are tall enough to permit spraying without hitting the tips which are easily injured. 2, 4-D (salt) can be used at the rate of 1/2 to 3/4 lb./acre with the higher rate for the early application. Do not use the ester form of 2, 4-D in raspberries. Do not use 2, 4-D during the blooming stage. DNBP (amine) can be used at 2 to 4 lbs. per acre. Use the higher concentration for the early spray and the lower rate for the later sprays when the newly-emerged canes are tender. A minimum amount of spray should contact the base of the canes. DNBP is effective only while the grasses and broadleaved weeds are small.

CIPC, 6 pounds per acre, applied in October or November appears promising for the suppression of common chickweed and fall-germinating grasses. Dalapon, 5 pounds per acre, also appears promising as a fall spray.

Grapes. Where weeds beneath the trellis cannot be controlled effectively by the grape hoe they may be controlled by treatment with contact herbicides such as

oil emulsions fortified with DNBP or PCP. Use 2 lbs. of DNBP, 15 gallons of aromatic or fuel oil and make up to 100 gallons with water. Four pounds of PCP may be substituted for the DNBP in the above mixture. Use a suitable emulsifying agent and make certain that the oil remains emulsified. Apply at the rate of 50 gallons per acre in an 18 inch strip beneath the trellis. Use a low pressure sprayer with a fan type nozzle. Keep the spray off the foliage and do not spray young vines which are not yet protected by a coating of loose bark.

Both CMU, 2 pounds per acre and CIPC, 10 to 14 pounds per acre have shown considerable promise for use in mature vineyards. One application per season is usually adequate

Grapes are extremely sensitive to hormonal type herbicides such as 2, 4-D.

Strawberries. In most seasons weeds in newly set strawberry fields can be controlled by mechanical cultivation up until the time that runner plants begin to set. After this time considerable hand labor is required to keep the row free of weeds. Strawberries are somewhat tolerant to hormonal type herbicides and 2, 4-D and sodium 2, 4-dichlòrophenoxyethyl sulfate (SES) are the most promising herbicides for use in this crop.

Pre-planting treatments with 2, 4-D (amine salt) have shown promise at the rate of 2 to 3 pounds per acre (higher rates for clay soils and soils high in organic matter and lower rates for sandy soils) where the soil is disturbed little in the planting operation. 2, 4-D may be used as a selective foliage spray at the rate of 1 lb. per acre during the period from 3 to 4 weeks after setting until late August when fruit bud differentiation begins. Treatment at the time of runner initiation usually causes a marked inhibition of runners.

To be effective against grasses 2, 4-D must be applied no later than the germination stage. For the control of over-wintering weeds 2, 4-D at the rate of 1 1/2 pounds per acre has given excellent control of susceptible weeds. Application, however, must be delayed until after the period of fruit bud differentiation to prevent fruit deformity.

One pound or less of 2, 4-D may be used at the time of mulch removal if over-wintering weeds were not controlled in the late fall. One pound of 2, 4-D per acre may be used just before the fruit begins to ripen as an emergency measure if annual broad-leaved weeds threaten to take the field. 2, 4-D must not be applied during the blooming period. This material has an important place in weed control the second summer and can be used at the rates of 1 1/2 to 2 pounds per acre immediately after picking. Procedure: mow field; narrow row to desired width; spray.

Sodium, 2, 4-dichlorophenoxyethyl sulfate (SES) is an effective herbicide only after it has been changed to an active form in the soil by the micro-organisms. Due to the nature of this material it is less injurious than 2, 4-D to the strawberry plants but it is effective against weeds only in the germinating seedling stage. This material may be used immediately after setting at the rate 3 to 6 lbs. per acre but the preferred time of application is 2 to 3 weeks after the plants are set. Excellent weed control for three weeks or longer is usually obtained. Repeat applications may be made during the spring, summer and fall months as needed. Runner production is reduced only slightly at these rates. It appears safe to use during the critical period of fruit bud differentiation; however, further investigational work should be done with this material at this stage of growth.

Fall germinating overwintering weeds can also be controlled by DNBP (amine), 3 pounds per acre, in late fall or winter after the strawberries are fully dormant.

Where common chickweed is the principal fall-germinating weed, CIPC, 1 1/2 to 2 pounds per acre, applied in late October or November appears promising.

Herbicides may be applied to the whole field or applied only in a band over the row. Rates of application are based on the area sprayed and the actual amount of chemical applied will be 1/2 or less of the per acre rate in the case of band applications.

Flowers

Gladiolus. Pre-emergence treatments of 2, 4-D (ester or salt) at 2 pounds per acre (referring to the area actually sprayed), DNBP at 8 pounds per acre, and sodium 2, 4-dichlorophenoxyethyl sulfate (SES) at 3 to 6 pounds per acre will control most annual broadleaved weeds. Where annual grasses are the primary problem TCA, at 10 pounds per acre can be used. If both types of weeds are present a mixture of 1 pound 2, 4-D and 10 pounds TCA may be used.

Post-emergence treatments with 2, 4-D (salt) at the rate of 1 pound per acre, when the gladioli are six inches tall or before the leaf blades open, controls most of the weeds in the row. Considerable injury may result if higher concentrations of 2, 4-D are used and if the plants are treated in their later stages of growth.

Investigations indicate that SES is less injurious than 2, 4-D and can be used pre-emergence at the rate of 3 to 4 pounds per acre and post-emergence at similar rates.

Although cormels grown for size increase are more subject to injury than flowering size corms, SES can be applied at the rate of 3-4 pounds per acre before, or immediately after the leaf blades appear.

Chrysanthemums. SES may be used at the rate of from 3-4 pounds per acre in beds or in the nursery row 2-3 weeks after transplanting.

Control of Weeds in Woody Crop Plants, Particularly Forest and Ornamental Nurseries and Shelterbelts

Control of Brush on Future Nursery Planting Sites. See recommendations under section "Control of Woody Plants."

Control of Quack Grass and Field Bindweed on Future Nursery Planting Sites After Brush Removal. Application of 1/2 to 1 pound of 2, 4-D per acre in late fall or in the bud to bloom stage are effective for the control of field bindweed. A repeat application may be necessary to satisfactorily control seedlings.

Quack grass con be controlled by the application of TCA at the rate of 80-100 pounds per acre in the fall, to undisturbed sod, and at 25-70 pounds when combined with thorough cultivation. In drier areas cultivation prior to chemical application is suggested. Repeat

applications and cultivation may be necessary in the event of heavy infestations. In sub-humid regions the residual effect of late summer or fall applications can be expected to extend into the growing season following treatment. Effective temporary suppression may be secured from early spring foliage applications of from 5-8 pounds per acre of MH, followed 3-6 days later by plowing and working down. Crops subsequently transplanted or sown do not seem to be affected. Dalapon at the rate of 20 pounds per acre applied after mowing or cultivated after spraying will result in suppression or control.

Control of Weeds in Seedbeds and Transplant Beds Weeds can be controlled successfully with steam sterilization, methyl bromide, and other soil fumigants. For weed types which germinate in the upper soil horizon, granular calcium cyanamide, applied at the rate of from 50-75 pounds per 1000 square feet to a warm moist soil and worked into the upper 2-3 inches is also recommended, provided the area is not to be planted immediately. Stoddard solvent or equivalent aromatic oils may be used as contact herbicides for the control of small, broadleaved weeds and annual grasses in coniferous seedling and transplant beds. The rate of application varies from 25-75 gallons per acre, depending on the species and the stage of growth of the seedlings at the time of treatment.

Established Stock. For coniferous transplants and deciduous stock in rows, aromatic oils fortified with PCP or DNBP may be used between the rows. A low pressure sprayer with a hooded boom should be used to prevent drift. Because of the oil in the mixture, application to the base of the stem should be avoided.

Considerable hand labor can be saved by planting lining-out stock on the square to permit cross cultivation.

SES is a promising herbicide for use in many species of ornamental plants at specific stages of growth. Depending upon the species, there are several times during the season when the chemical may be applied directly to weed-free soil around the plants in the row. In general, the herbicide has not been satisfactorily employed for weed control during the cool temperatures which prevail early in the spring in the North Central Region. The large number of species found in our nurseries has made it impossible to test all of them for SES to date. Consult your own experiment station for information on the tolerance of the individual species and the proper amount to use on your soil type.

CIPC may be used at the rate of 6 lb./acre in October in newly established apple stool blocks. It may also be applied to mature stool blocks after cutting and leveling in November or for dormant season weed control in established nursery stock.

Turf

Broad-leaved Weeds. Control of annual broad-leaved weeds in new turf can be obtained by ordinary mowing and management practices which favor the development of turf grasses. Herbicidal sprays should not be applied until the turf is one year old.

In established turf certain perennial weeds can be controlled by applications of 2, 4-D made when the weeds are in active growth. Periods of active growth, in most of the North Central Region, occur in both spring and fall. Because of less risk of injury from drift to adjacent ornamental plantings, fall applications are generally preferred. The amine salt of 2, 4-D at a concentration of 0.1 to 0.2 percent acid equivalent, and a volume of 1 gallon per 1000 square feet, is adequate for many species. Better results on resistant species will be obtained when 2, 4-D esters are used but more damage from drift or volatization may occur.

Crabgrass. May be controlled by either of the following methods:

(1) Potassium cyanate, 3 ounces per 1000 square feet, preferably when crabgrass seedlings are not more than 2 inches in height. Repeat applications at 7 to 10 day intervals may be required.

(2) PMA, 0.3 ounce per 1000 square feet, as soon as crabgrass seedlings are observed. The applications must be repeated at 7 to 10 day intervals until 3 to 5 applications have been made.

MECHANICAL CONSIDERATIONS

Mechanical considerations in a comprehensive program of weed control include the proper use of seed cleaning, tillage, chemical application and harvesting equipment. No one machine or operation in the above group will give satisfactory weed control when used exclusively without regard for the others.

Seed cleaning. It is important that all seed used be free of weed seed. If no weed seed is planted, there will be less work for the tillage and chemical practices which follow and new weed species will not be introduced. Whether the seed is cleaned in the home mill or on a custom basis, the cleaned seed should be carefully checked to see that all the weed seed has been removed. If a special cleaning problem exists, many seed firms have specialized equipment to do the job.

Tillage equipment. The effectiveness of tillage operations is dependent upon the timing, speed, and adjustments of the implement. All three variables should be given careful consideration in connection with soil type, conditions and crop.

Adjustments are especially important in the use of the cultivator. It should give as much weed control as possible within the crop row and yet avoid injury to the tops or pruning of the roots.

Sprayers. In buying a farm weed sprayer, careful consideration should be given to its service and possible repair. For this reason reputable dealers and manufacturers capable of furnishing service and parts are the best source of equipment.

In the selection of a weed sprayer, consideration should be given to other operations likely to require use of a sprayer around the farm. Of special importance is the choice of the pump and the sprayer mounting.

Equipment should be constructed of materials which are resistant to corrosion by the common herbicides. Stainless steel and polyester resins reinforced with fiberglass appear to be the most resistant. Aluminum, brass, and galvanized iron are resistant but in some cases may require special flushing or other precautionary measures. Examples of such instances are the use of aluminum with TCA and brass with ammate.

Materials, coatings, hose and gasket material which are not affected by the oils and solvents used with these herbicides should be used. Natural rubber has poor resistance to many petroleum derivatives. Some coating materials may provide good corrosion resistance but such resistance is greatly reduced by scratches or breaks in the coating.

Some of the desirable features of a serviceable weed sprayer are as follows:

Tank. The tank should be strong enough to withstand the pressures of the fluid inside and of a size which can be easily maneuvered through the field. The tank size should also be considered on the basis of the amount of spray to be applied per acre. Provisions should be included for easy and complete draining. An opening should be provided which will allow for cleaning the inside when necessary. It is important to have agitation within the tank either by mechanical means or by sufficient by-pass from the discharge line.

Suction strainer. This strainer should be fine enough and of sufficient strength to remove as much foreign material as possible from the solution but of a size that will not throttle the suction of the pump. Inasmuch as this requires a compromise, special emphasis should be put on care in filling the tank. The strainer should be easily removable for cleaning.

Pump. The pump should be of sufficient capacity and quality to maintain adequate working pressures and flow to meet the conditions set by the spraying operation. It can be expected that most pumps will lose a part of their efficiency through normal use. The choice of capacity of power take-off operated pumps should allow for their possible use on those tractors which will have a reduced p.t.o. speed under many spraying conditions.

Regulating valve and pressure gauge. These two items should be within easy reach and sight of the operator. The marked increments of the gauge should be such that pressures can be judged accurately over the full range of spraying pressures contemplated.

Boom. Booms should be suitably hinged to reduce breakage and to permit convenient transportation. They should be of sufficient size to prevent a significant pressure drop at the end nozzles and have removable plugs in the ends to facilitate cleaning. In view of the wide range of recommended spray application rates, special care and attention should be given to the selection and performance of the nozzles. They should be uniform in output and in the spray pattern which each produces.

Other features essential to a good sprayer are a quick acting shutoff valve, line filter between the pump and boom, individual filters at each nozzle and some device for measuring the fluid in the tank.

Calibration. Even distribution is the most important characteristic of a good sprayer. Each nozzle and each square foot of area must be checked for even pattern and consistently even spraying. The sprayer output should be calibrated to each particular spraying operation. The best method of calibration is the making of initial adjustments to suit the machine and job requirements and then making a trial run to determine the actual output of the machine. The herbicide should then be mixed accordingly. The calibration should be checked frequently during the operation to check for such things as nozzle orifice wear. This is especially important when abrasive solutions are used.

Maintenance. A strict cleaning program should be followed after each use of the sprayer. This should include not only flushing the tank, pump, boom, and nozzles, but also cleaning the exterior of the equipment. When the sprayer is prepared for winter storage, all bare metal parts should be coated with oil, the hoses should be disconnected, the pumps flushed with oil, and their drain plugs removed. The nozzles should be disassembled, cleaned and kept in a container of oil.

Broadcast nozzles. The broadcast nozzle may prove very useful for spraying roadsides, fencerows, brush pastures, and other areas for which boom type sprayers prove awkward, and for spraying field crops when there is considerable difference between the tolerance of the crop and that of the major weeds to the chemical used. The swath width recommended by the manufacturer must be followed closely. Most uniform results can generally be obtained at 30 psi pressure in still air (less than 4-7 mph wind). Double coverage by overlapping half a swath will enable the operator to control his swath width better and will give much more uniform coverage. Calibration is just as important as with conventional sprayers, and should be based on the actual effective swath width.

Harvesting equipment. As an aid in preventing the spreading of weed seed, it is important that a strict cleaning program be set up and adhered to before moving the machine from the field. Each machine should be inspected to determine the places (flat areas, corners, and depressions) where weed seed is prone to collect during normal operation. The removing of dirt and weed seed from such places by compressed air, brushes, or other special equipment should be included in the cleaning process.

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RECOMMENDATIONS OF THE COMMITTEE ON TERMINOLOGY

The committee recommends the use of the terms, definitions, and abbreviations listed in this report in the preparation of abstracts, reports, and articles that have to do with weed control. The use of the recommended forms, definitions, etc. is especially desirable in the preparation of short reports in order to conserve space and to make for easier interpretation of results by project leaders and readers in general.

Trade Names and Code Numbers usually should not be used. The Research Committee has ruled that reports on materials by code number or trade name only shall not be used in preparing summaries. Some highly complex organic herbicides have been introduced under trade names. As long as these products are made by only one company, the trade-marked names (always capitalized) may be used in the body of an article or abstract. The first time such a product is mentioned in a research report, the full chemical name should be given, followed by the trade name in parentheses.

Chemical Names and Designations. Chemical symbols should not be combined with alphabetical abbreviations in designating compounds, for instance, the sodium salt of TCA should not be stated as NaTCA. In the list which

follows, the chemical name is given in (a) followed in (b) by common names of basic compounds (c)common derivatives of basic compound.

Rates and concentrations for materials listed in items, 1, 2, 3, 4 and 5 should be stated as the acid equivalent.

1. (a) 2, 4-dichlorophenoxyacetic acid
   (b) 2, 4-D
   (c) 2, 4-D, salt (indicate which)
   2, 4-D, ester (indicate which)

2. (a) 2, 4, 5-trichlorophenoxyacetic acid
   (b) 2, 4, 5-T
   (c) 2, 4, 5-T, salt (indiçate which)
   2, 4, 5-T, ester (indicate which)

3. (a) 2-methyl-4-chlorophenoxyacetic acid
   (b) MCP
   (c) MCP, salt (state which)
   MCP, ester (state which)

4. (a) trichloroacetic acid
   (b) TCA
   (c) TCA, salt (state which)

5. (a) N-1-naphthyl phthalamic acid
   (b) NP
   (c) NP, salt (state which)

Rates and concentrations for materials listed in items 6, 7, 8 and 9 should be stated as the phenol equivalent.

6. (a) pentachlorophenol
   (b) PCP
   (c) PCP, sodium salt (rates have usually been stated in terms of the salt)

7. (a) 4, 6-dinitro-o-cresol
   (b) DNC
   (c) DNC, salt (state which)

8. (a) 4, 6-dinitro-o-sec-butylphenol
   (b) DNBP
   (c) DNBP, salt (state which)

9. (a) 4, 6-dinitro-o-sec-amylphenol
   (b) DNAP
   (c) DNAP, salt (state which)

Rates and concentrations for all the following materials should be stated as pounds or ounces of active ingredient.

10. (a) phenyl mercuric acetate
    (b) PMA

11. (a) isopropyl-N-phenylcarbamate
    (b) IPC

12. (a) isopropyl-N-(3-chlorophenyl) carbamate
    (b) CIPC

13. (a) 3-p-chlorophenyl-1-1-dimethylurea
    (b) CMU

14. (a) 3, 6-endoxohexahydrophthallic acid
    (b) endothal

15. (a) sodium 2, 4-dichlorophenoxyethyl sulfate
    (b) SES

16. (a) potassium cyanate
    (b) KOCN

17. (a) Maleic hydrazide
    (b) MH

All other compounds should be listed by their full chemical names.

DEFINITIONS

1. Pre-emergence applications are those made after crop is planted but before it emerges and are of two kinds: (1) contact pre-emergence - an application made after weed emergence and (2) residual pre-emergence which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.

2. Soil sterilant. A material which renders the soil incapable of supporting plant growth. Sterilization may be temporary or relatively permanent.

3. Contact herbicide. An herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

4. Low volatility, as applied to herbicides such as 2, 4-D, 2, 4, 5-T and other similar compounds, is a relative term. Differences in volatility are real and important, but so far, can be determined only by biological tests.

5. Low volatile esters. The esters of 2, 4-D, 2, 4, 5-T and other similar herbicidal compounds that have low volatility should not be designated as non-volatile esters.

6. Spray drift. The movement of airborne spray particles from the spray nozzle outside the intended contact area.

7. Vapor drift. The movement of herbicidal vapors from the area of application to adjacent areas.

8. Rate and dosage. These terms are synonomous. "Rate" is the preferred term. Rate refers to the amount of active material (such as 2, 4-D acid equivalent) applied to a unit area (such as one acre) regardless of percentage of chemical in the carrier.

9. Concentration. Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.

10. Herbicide. A chemical known to be toxic to some chlorophyll-bearing plants.

11. Dormant treatment of deciduous woody plants refers to applications of herbicides made during the period after leaf-fall, or death of leaves, and before bud-break.

12. Basal treatment. A basal treatment is an application to the stems of plants at and just above the ground line.

13. Alphabetical designations for chemical compounds should be capital letters (upper case) without spacing or periods; for example MCP, PCP.

ABBREVIATIONS

The use of the following abbreviations is recommended and, unless otherwise indicated, should be small letters (lower case) without spacing or periods:

acid equiv. per 100 gal.	ahg
acre	A
bushel or bushels	bu
diameter	diam
foot or feet	ft
feet per minute	fpm
gallon or gallons	gal
inch or inches	in
miles per hour	mph
parts per million	ppm
pint or pints	pt
pound or pounds	lb
pounds per sq. in	psi
quart or quarts	qt
rate per acre gal/A, oz /A, lb/A,	bu/A
revolutions per minute	rpm
square	sq
weight	wt

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WEED ESSAY CONTEST

At the meeting of the Board of Directors of the North Central Weed Control Conference held December 8, 1954 at Fargo, N. D. the following resolution was adopted:

"That the Weed Essay Competition Committee go on record as favoring for 1955, the continuation of the essay contest entitled 'How We Control Weeds On Our Farm' to be open to any boy or girl of the N. C. W. C. C. between the ages of 12-18 inclusive. Furthermore the committee urges full participation of all states and provinces of the North Central Weed Control Conference. The responsibility for the administration of the contest be delegated to the state or the provincial director on the Board of Directors of the N. C. W. C. C."

The following rules shall govern the essay competition:

1. Who shall be eligible: Any boy or girl, 12-18 years inclusive, within the state or province encompassed by the North Central Weed Control Conference.
2. Title: "How We Control Weeds On Our Farm".
3. Length: The essay shall not exceed 1000 words in length.
4. How Written: The essay shall be typewritten or written in ink in the English language on one side of the paper only. The writer's name, address, and age shall be on the reverse side of the first page.
5. Submitting Essay: Each competition shall mail or deliver his or her essay to the designated person or persons as arranged by the state or provincial director of the N. C. W. C. C., the date line to be set by each state or provincial director.
6. Basis of Judging Essays: Subject material - 75%; method of presentation - 25%.
7. Judging Essays: Each state or province shall determine its own method of judging the winning essay which shall be submitted to the Chairman of the Essay Competition of the N. C. W. C. C. on or before November 1, 1955.
8. Awards:
    1. The winning essay from each state or province shall be eligible for an award of $25.00.
    2. The winner of the high scoring essay from the several states and provinces participating shall be awarded a scholarship to the value of $300.00 under the terms of the report of the North Central Weed Control Conference Finance Committee as accepted by the Board of Directors of the N. C. W. C. C. at its meeting in Kansas City, December 1953 to wit: "This scholarship shall be available at time of registration in a recognized agricultural college in courses of agriculture or home economics of the individuals choosing, provided that such courses lead to a degree or diploma. Payment of the scholarship fee shall be made to and disbursed by the proper financial official of the chosen institution. The limit for acceptance of the scholarship award is to be a maximum of three (3) years after graduation from high school."

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RESOLUTIONS

The Resolutions Committee hereby moves the adoption of these resolutions, and instructs the Secretary of the Conference to take the necessary steps and appropriate action concerning them.

WHEREAS, the NCWCC has greatly enjoyed the excellent arrangements and facilities provided for holding this 11th Annual Conference,

NOW THEREFORE BE IT RESOLVED that we express our appreciation and thanks to the State of North Dakota, the city of Fargo, the Fargo Chamber of Commerce, the Manager of the Gardner Hotel, the Staff of the North Dakota Department of Agriculture, and more particularly to E. A. Helgeson and R. B. Widdifield, Co-Chairmen of Local Arrangements Committee; and to the Chairman of the Program Committee, L. G. Holm; and to the many other individuals and organizations who have helped to make this Conference a complete success. Furthermore, that we express our thanks to the Midwest Farm Paper Unit for the attractively designed and excellently printed program.

FURTHERMORE, BE IT RESOLVED that this Conference express its thanks to Dr. H. L. Walster, Retired Dean of Agriculture and Director of the Agricultural Experiment Station, North Dakota Agricultural College for his interesting and inspiring address.

WHEREAS, this Conference is indebted to Dr. M. W. Parker, Head, Section of Weed Investigations, Field Crops Research, United States Department of Agriculture for his informative address, and

WHEREAS, his presence at, and contribution to, this 11th Annual Meeting of the North Central Weed Control Conference is greatly appreciated,

NOW, THEREFORE, BE IT RESOLVED that this Conference express its thanks to Dr. Parker, and commend him for the excellent weed research program he is developing and for his leadership in this aspirant field of crop research.

WHEREAS, great losses to Agriculture are caused by noxious weeds, and,

WHEREAS, there is a serious problem resulting from the movement of feed and other materials infested with noxious weed seeds and propagating plant parts:

THEREFORE, BE IT RESOLVED that this Conference urges that Federal legislation be enacted to regulate the movement of such infested materials, other than agricultural seeds, in interstate commerce, and that this provision comply with State laws regulating the movement of such infested materials; or that such interstate movement of infested materials be directly under specific regulations of the Federal law.

WHEREAS, there is a growing need for a broad organization of national scope to further all aspects of weed and weed control work,

THEREFORE BE IT RESOLVED that the 11th Annual meeting of the North Central Weed Control Conference go on record as favoring the organization of an "American Weed Society".

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Registration List

ELEVENTH ANNUAL NORTH CENTRAL

WEED CONTROL CONFERENCE

Fargo, North Dakota, December 6-9, 1954

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Yoke, Morrell L., Waterville, Ia.
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Zick, Warren H., 4313 Lumley Rd., Madison 5, Wis.
Zinter, Clinton C., 912 Grain Exchange, Minneapolis, Minn.
Zorsch, Charles P. 800 N. 12 Blvd., St. Louis, Mo.

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LIST OF MEMBER COMMERCIAL ORGANIZATIONS

Agsco Chemicals, Inc., P. O. Box 351, Grand Forks, N. D.
American Chemical Paint Co., Ambler, Pa.
Associated Dealers Supply, Willmar, Minn.
R. H. Boyle Co., Alexandria, Va.
California Packing Corp., (Midwest Div.), P. O. Box 89, Rochelle, Ill.
Chipman Chemicals, Ltd., 1040 Lynn Ave., Winnipeg, Man.
Columbia-Southern Chemical Corp., Agr. Chem. Div., 1 Gateway Center, Pittsburgh, Pa.
Davey Tree Expert Co., Kent, Ohio
Delavan Mfg. Co., Grand Ave. & 4th St., West Des Moines, Iowa
Deere & Co., Moline, Ill.
Dow Chemical Co., Midland, Mich.
E. I. DuPont de Nemours & Co., Inc., 10 & Market St., Wilmington 98, Del.
Export Chemical Corp. of Colo., Denver, Colo.
Fargo Foundry Co., Fargo, N. D.
Farmers Union Central Exchange, Inc., P. O. Box B, St. Paul 1, Minn.
Farmrite Sprayer, Inc., Clyman, Wisc.
Flax Development Committee, P. O. Box 926, Minneapolis 2, Minn.
Food Machinery & Chemical Corp., Lansing 4, Mich.
Geigy Agr. Chemicals, Burlington, Ia.
Green Giant Co., LeSueur, Minn.
Gresen Mfg. Co., 628 Colfax Ave. N., Minneapolis 11, Minn.
Hahn, Inc., 315 N. 9 Ave., Evansville, Ind.
Hanson Chemical Equipment Co., Beloit, Wis.
Heyden Chemical Corp., 342 Madison Ave., New York, N. Y.
H. D. Hudson Mfg. Co., 589 E. Illinois, Chicago 11, Ill.
Hypro Engineering, Inc., 404 Washington Ave., N., Minneapolis 1, Minn.
Illinois Farm Supply Co., 100 E. Ohio St., Chicago, Ill.
International Elevator Co., Grain Exchange Bldg., Minneapolis, Minn.
N. S. Koos & Son Co., Kenosha, Wis.
O. W. Kromer Co., 1120 Emerson Ave. N., Minneapolis 11, Minn.
Mathieson Chemical Corp., Agr. Chem. Development, Mathieson Bldg., Baltimore, Md.
McConnon & Co., Winona, Minn.
M. F. A. Oil Co., Columbia, Mo.
Midway Distributors, Inc., Huron, S. D.
Miller Chemical Co., Inc., 15 & California Sts., Omaha 2, Nebr.
Monsanto Chemical Co., 800 N. 12 Bldv., St. Louis 1, Mo.
Mutual Dealers Wholesale, Inc., St. Paul 14, Minn.
National Aluminate Corp., Chicago, Ill.
National Assoc. of Mfgs. of Spraying & Dusting Equip., Board of Trade Bldg., Chicago, Ill.
National Grain Co., Ltd., Winnipeg, Man.
Niagara Chemical Div., Food Mach. & Chem. Corp., Middleport, N. Y.
Northrup, King & Co., 1500 Jackson St. N. E., Minneapolis, Minn.
Oldbury Electro-chemical Co., 19 Rector St., New York, N. Y.
Pacific Coast Borax Co., P.O. Box 9128, Sanford Station, Los Angeles 5, Calif.
F. H. Peavey & Co., Minneapolis 15, Minn.
Pennsylvania Salt Mfg., Co., 100 Widener Bldg., Philadelphia, Pa.
Private Brands, Inc., Kansas City, Kans.
Riverside Chemical Co., 324 E. 147 St., Riverdale, Ill.
J. C. Robinson Seed Co., Waterloo, Nebr.
Spraying Systems Co., 3201 Randolph St., Bellwood, Ill.
Standard Oil Co., Chicago, Ill.
Thompson Chemicals Corp., 3028 Locust, St. Louis 3, Mo.
Thompson-Hayward Chemical Co., 2915 S. W. Blvd., Kansas City 8, Mo.
Tryco Mfg. Co., Inc., P. O. Box 1277, Decatur, Ill.
Twin-Draulic, Inc., Laurene, Ia.
Union Carbide & Carbon Corp., 30 E. 42 St., New York, N. Y.
W. H. Barber Co., (Naval Stores Dept.), Minneapolis, Minn.
Woodbury Chemical Co., 702 S. 4 St., St. Joseph, Mo.

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LIST OF EXHIBITORS

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The Broyhill Co., Dakota City, Nebr.
Campbell Mfg. Co., 114 N. Broadway, Fargo, N. D.
Carbide & Carbon Chemicals Co., 30 E. 42 St., New York 17, N. Y.
Chipman Chemical Co. Inc., Boundbrook, N. Jersey
Delavan Mfg. Co., 811 4 St., West Des Moines, Ia.
E. I. DuPont de Nemours & Co., Inc., 10th & Market St., Wilmington 98, Del.
Fargo Farm Equipment Sales Co., Fargo, N. D.
Fargo Foundry Co., Fargo, N. D.
Farmers Union Central Exchange, Inc., 1200 N. Concord St., So. St. Paul, Minn.
Geigy Agr. Chemicals, Div. of Geigy Chemical Corp., 89 Barclay St., New York 8, N. Y.
General Chemical Div., Allied Chemical & Dye Corp., 220 Bdwy. St. N.E., Mpls., Minn.
Hanson Chemical Equipment Co., Beloit, Wis.
Hypro Engineering Inc., 404 Washington Ave., N., Minneapolis 1, Minn.
Oberdorfer Foundries, Inc., Syracuse 1, N. Y.
Oldbury Electro-Chemical Co., 19 Rector St., New York 6, N. Y.
Pacific Coast Borax Co., 630 Shatto Place, Los Angeles 5, Calif.
F. H. Peavey & Co., 912 Grain Exchange, Minneapolis 15, Minn.
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Sears, Roebuck & Co., Fargo, N. D.
Spraying Systems Co., 3201 Randolph St., Bellwood, Ill.
Standard Oil Co., Fargo, N. D.
Thompson-Hayward Chemical Co., 2915 S. W. Blvd., Kansas City 8, Mo.
West Fargo Mfg. Co., West Fargo, N. D.

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